Physics · Electric Current and Electromagnetism · Magnetic Effect of Electric Current and Measuring Instruments

Magnetic Force and Torque

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questions	sets	pages

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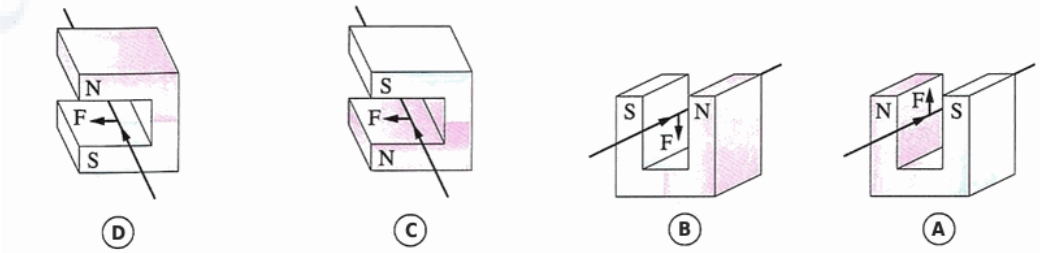
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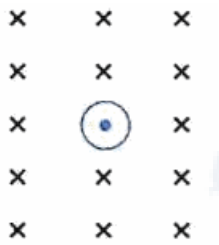
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Multiple choice questions — 116 questions

1 In each of the following figures, a straight wire carrying an electric current is placed in a magnetic field. In which figure is the direction of the magnetic force acting on the wire correct?

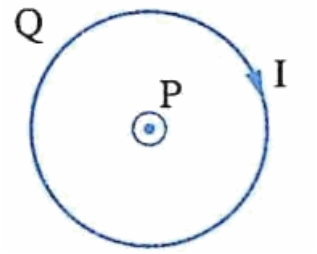


2 In the opposite figure, a wire of length (ℓ) carries a current (I) out of the page and is placed in a magnetic field of flux density B directed into the page. The magnetic force acting on it equals .....



(A) BIℓ (B) *1/2* BIℓ (C) √*(2)* BIℓ (D) 0

3 A circular coil Q carries an electric current (I). A long straight wire P carrying a current out of the page is placed at the centre of the coil, perpendicular to its plane, as in the opposite figure. The wire P .....



(A) is acted on by a magnetic force out of the page

(B) is acted on by a magnetic force into the page

(C) is not acted on by any magnetic force

(D) is acted on by a magnetic force in the plane of the page

4 A wire carrying a current of 10 A is placed perpendicular to a magnetic field of flux density 0.1 T. The magnetic force acting on a unit length of the wire equals .....

(A) 1 N/m (B) 2.5 N/m (C) 3 N/m (D) 4.6 N/m

5 A wire of length 10 cm carrying a current of 5 A is placed in a magnetic field of flux density 1 Wb/m². The magnetic force acting on the wire when it makes an angle with the direction of the flux lines of:

0° is .....

(A) 0.3 N (B) 0.11 N (C) 0 (D) 0.7 N

6 A wire of length 10 cm carrying a current of 5 A is placed in a magnetic field of flux density 1 Wb/m². The magnetic force acting on the wire when it makes an angle with the direction of the flux lines of:

45° is .....

(A) 0.354 N (B) 0.631 N (C) 0.891 N (D) 0.913 N

7 A wire of length 10 cm carrying a current of 5 A is placed in a magnetic field of flux density 1 Wb/m². The magnetic force acting on the wire when it makes an angle with the direction of the flux lines of:

90° is .....

(A) 0.25 N (B) 0.5 N (C) 0.7 N (D) 1 N

8 A wire of length 10 cm carrying a current of 5 A is placed in a magnetic field of flux density 1 Wb/m². The magnetic force acting on the wire when it makes an angle with the direction of the flux lines of:

135° is .....

(A) 0.221 N (B) 0.354 N (C) 0.496 N (D) 0.532 N

9 A wire of length 10 cm carrying a current of 5 A is placed in a magnetic field of flux density 1 Wb/m². The magnetic force acting on the wire when it makes an angle with the direction of the flux lines of:

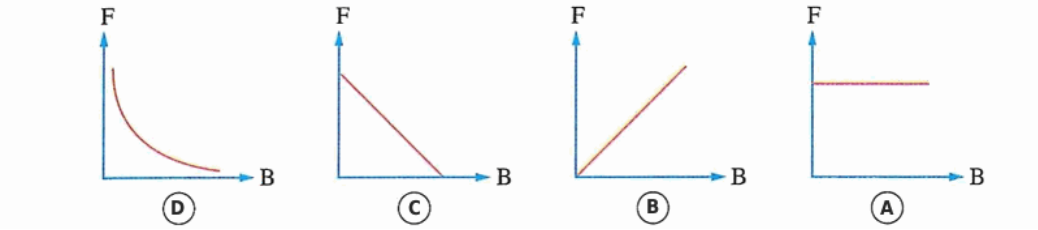
180° is .....

(A) 0 (B) 0.25 N (C) 0.5 N (D) 1 N

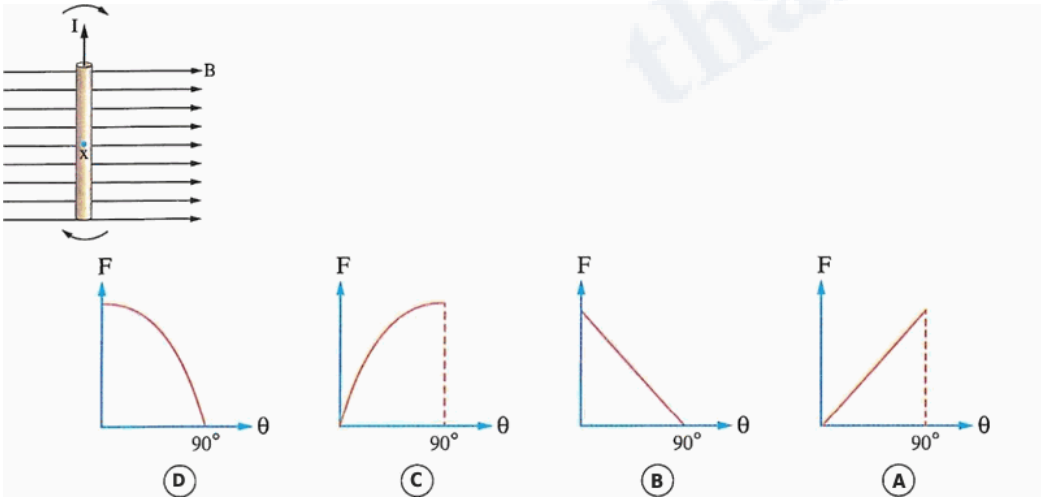
10 A straight wire of length 30 cm carries a current of 4 A. The angle this wire makes with a magnetic field of flux density 5 T so that a magnetic force of 3 N acts on it equals .....

(A) 30° (B) 45° (C) 60° (D) 90°

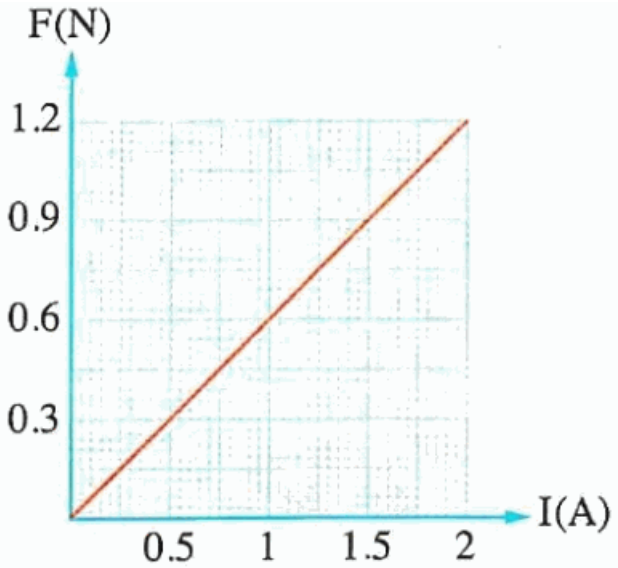
11 A straight wire carrying an electric current is placed perpendicular to a magnetic field whose flux density (B) can be changed uniformly. The graph that represents the relation between the magnetic force (F) acting on the wire and the magnetic flux density (B) is .....



12 In the opposite figure, a straight wire carrying an electric current (I) is placed perpendicular to a uniform magnetic flux of density B. If the wire is rotated through 90° about an axis perpendicular to its length at point x, the graph that represents the relation between the magnetic force (F) acting on the wire and the angle of rotation (θ) is .....

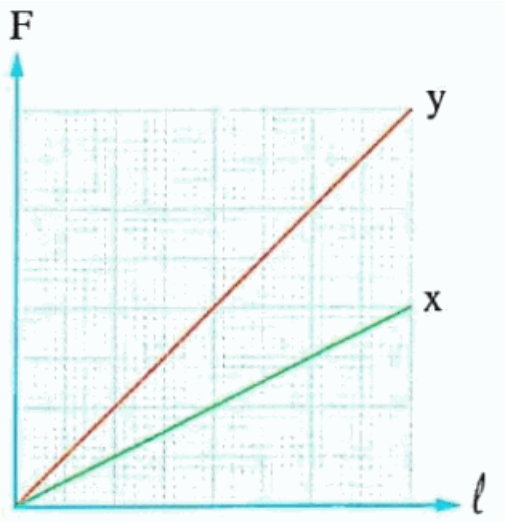


13 The opposite graph represents the relation between the magnetic force (F) acting on a straight wire of length 60 cm placed perpendicular to a uniform magnetic field and the current (I) in the wire. The magnetic flux density acting on the wire equals .....



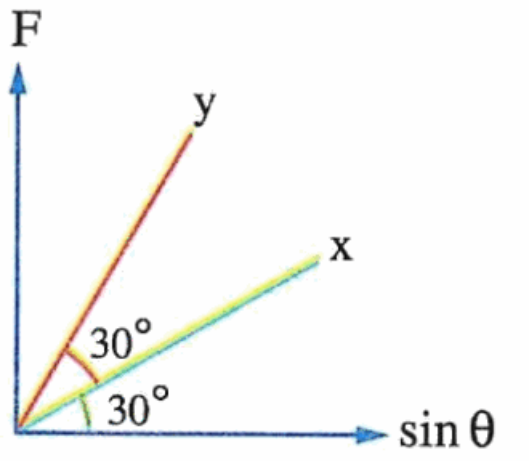
(A) 0.01 T (B) 0.1 T (C) 1 T (D) 1.01 T

14 Two groups of wires (x) and (y) carry electric currents of the same value (I) and are placed in a uniform magnetic field of flux density (B), so that the wires of group (x) are inclined at an acute angle (θ) to the direction of the field and the wires of group (y) are perpendicular to the field. The opposite graph represents the relation between the magnetic force (F) acting on each wire and its length (ℓ). The angle (θ) equals .....



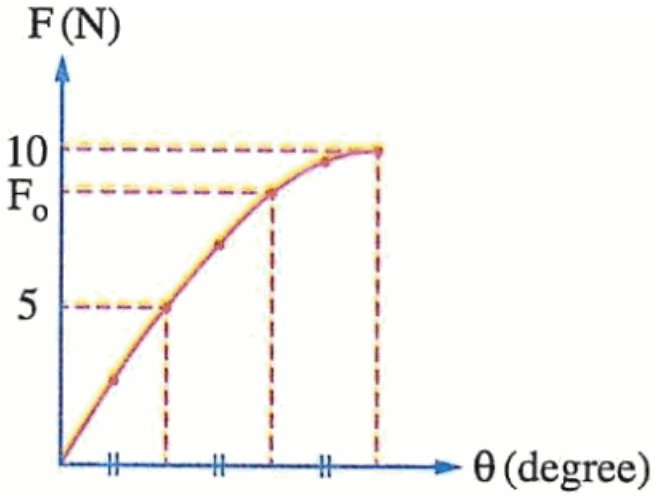
(A) 15° (B) 30° (C) 45° (D) 60°

15 Two wires (x) and (y) of the same length carry electric currents I_x and I_y respectively and are rotated in the same uniform magnetic field. The opposite graph represents the relation between the magnetic force (F) acting on each wire and the sine of the angle between the wire and the direction of the field (sin θ). The ratio (I_x/I_y) equals .....



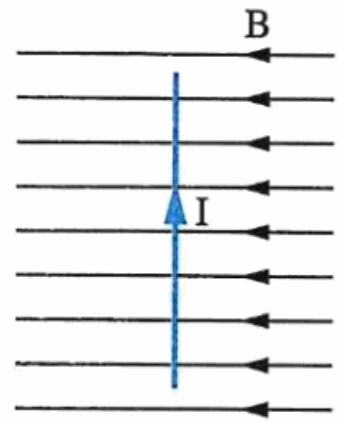
(A) $1/(\sqrt{3})$ (B) $\sqrt{3}$ (C) $1/3$ (D) 3

16 A straight wire carrying an electric current is rotated in a uniform magnetic field. The opposite graph represents the relation between the magnetic force (F) acting on the wire and the angle of rotation of the wire (θ) as it rotates a quarter of a turn from the position parallel to the field. The value of the force (F_o) shown in the figure equals .....



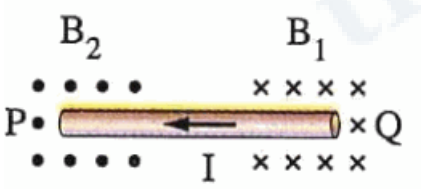
(A) $5\sqrt{2}$ N (B) 7.5 N (C) 8 N (D) $5\sqrt{3}$ N

17 A wire of length 2 m carrying an electric current of 5 A is placed perpendicular to a magnetic flux of density 0.4 T directed as in the opposite figure. The magnitude and direction of the magnetic force acting on the wire are .....



(A) 2 N, out of the page
(B) 2 N, into the page
(C) 4 N, out of the page
(D) 4 N, into the page

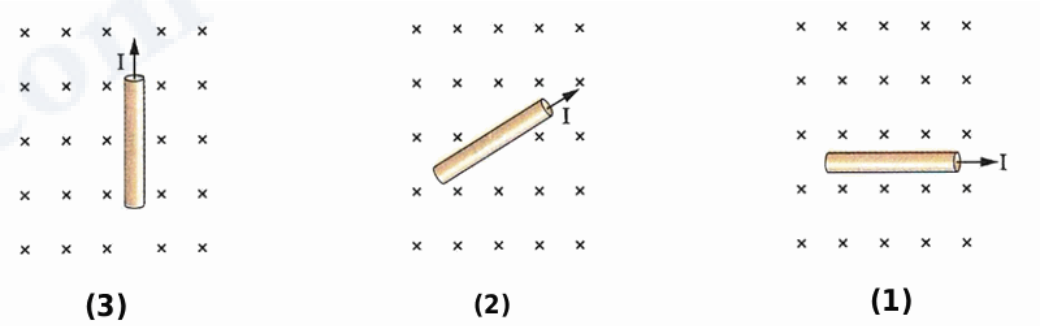
18 The opposite figure shows a straight wire PQ, free to move in the plane of the page, carrying an electric current I, with two uniform magnetic fields acting on its two ends. Which of the following choices shows the direction of motion of the two ends of the wire?



(A) End P: perpendicular to the page and outward, end Q: perpendicular to the page and inward
(B) End P: perpendicular to the page and inward, end Q: perpendicular to the page and outward
(C) End P: in the plane of the page upward, end Q: in the plane of the page downward
(D) End P: in the plane of the page downward, end Q: in the plane of the page upward

19 The following figures show a wire carrying an electric current (I) in different positions in a uniform magnetic field.

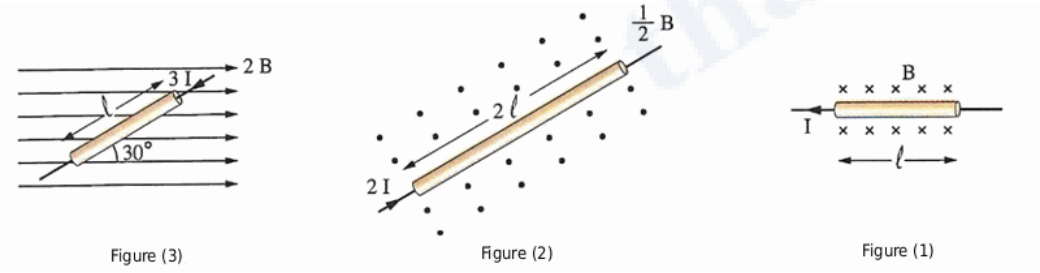
The wire is acted on by the greatest magnetic force in position .....



(A) (1)
(B) (2)
(C) (3)
(D) The force is equal in all positions

20 In the following figures, three wires each carry a direct electric current and are placed in a uniform magnetic field.

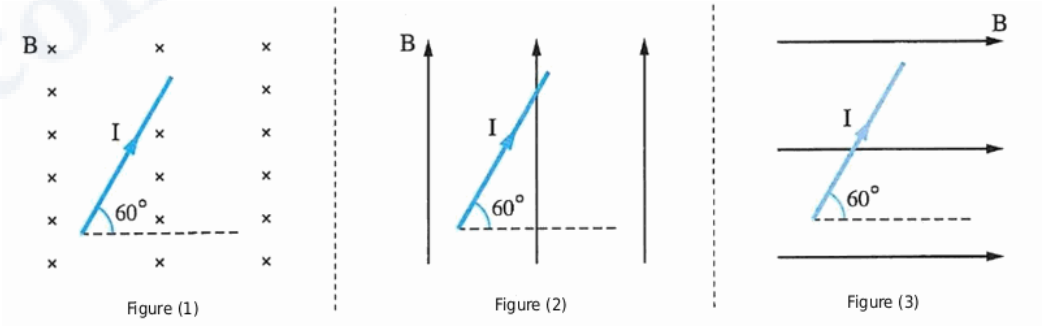
Which of the following represents the relation between the magnitudes of the magnetic forces acting on the wires?



(A) $F_1 > F_2 > F_3$ (B) $F_2 > F_1 > F_3$ (C) $F_3 > F_2 > F_1$ (D) $F_3 > F_1 > F_2$

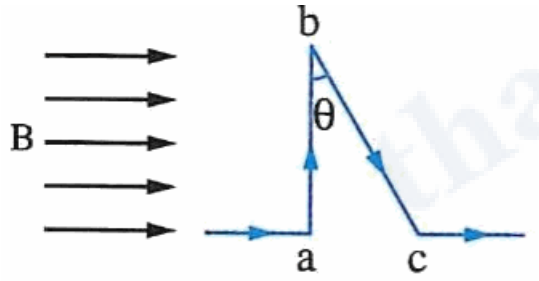
21 A straight wire carrying an electric current (I) is placed in three uniform magnetic fields of the same flux density but different directions, as in the following figures.

The correct order of the figures according to the magnitude of the magnetic force acting on the wire is .....



(A) (1) = (2) = (3) (B) (1) > (2) > (3) (C) (1) > (3) > (2) (D) (2) > (3) > (1)

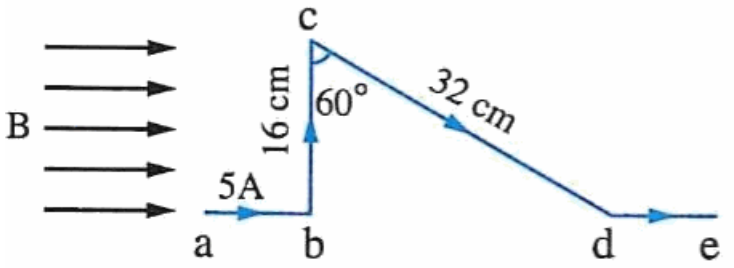
22 In the opposite figure, if the magnetic force acting on side ab is F, then the magnitude of the force acting on side bc is .....



(A) less than F (B) greater than F (C) equal to F (D) equal to F sin θ

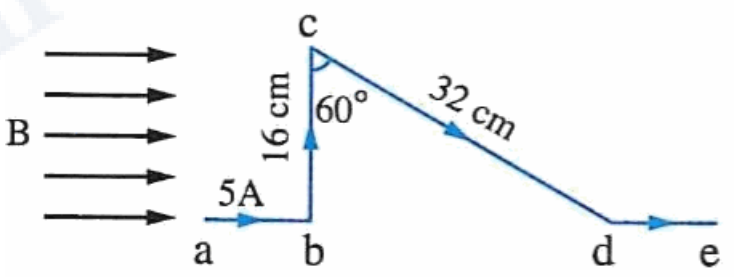
23 In the opposite figure, if the current in the wire is 5 A and the flux density is 0.15 T, the magnetic force acting on part:

ab of the wire due to this flux equals .....



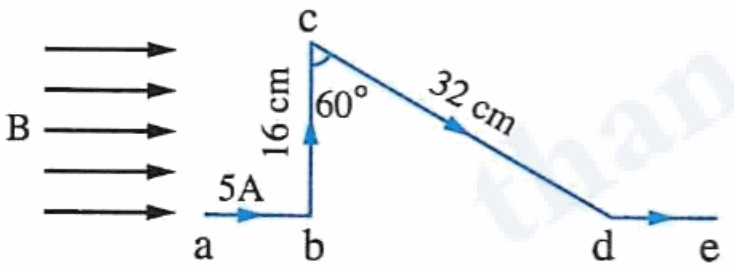
(A) 0.24 N (B) 0.12 N (C) 0.06 N (D) 0

24 In the opposite figure, if the current in the wire is 5 A and the flux density is 0.15 T, the magnetic force acting on part:
bc of the wire due to this flux equals .....



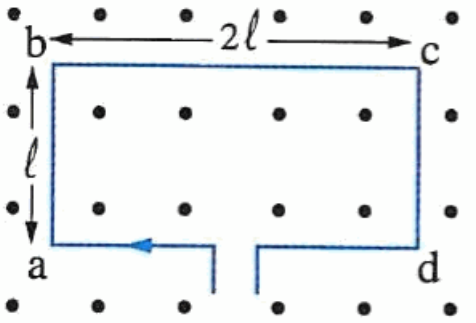
(A) 0.36 N (B) 0.25 N (C) 0.12 N (D) 0

25 In the opposite figure, if the current in the wire is 5 A and the flux density is 0.15 T, the magnetic force acting on part:
cd of the wire due to this flux equals .....



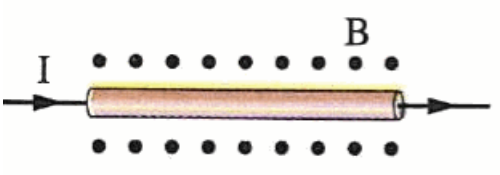
(A) 0.45 N (B) 0.37 N (C) 0.23 N (D) 0.12 N

26 The opposite figure shows a rectangular coil abcd carrying an electric current, placed in the plane of the page in a magnetic field perpendicular to the page. The ratio between the magnetic force acting on side ab and the magnetic force acting on side bc $((F_{ab})/(F_{bc}))$ is .....



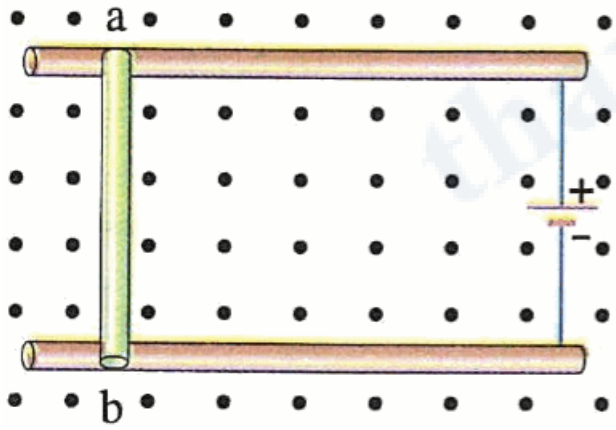
(A) greater than one (B) less than one (C) equal to one (D) equal to zero

27 A wire of weight F is hung horizontally, parallel to the Earth's surface, so that it is perpendicular to a magnetic field of flux density B as in the figure. If an electric current passes through the wire, a magnetic force of 2F acts on it. The magnitude of the resultant of the wire's weight and the magnetic force acting on it is .....



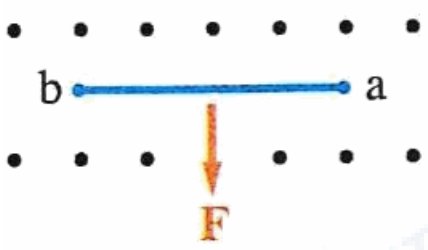
(A) F (B) 2 F (C) $\sqrt{(5)}$ F (D) 3 F

28 A cylindrical metal rod ab of length 20 cm, resistance 2 Ω and mass 400 g can move on two smooth copper rails of negligible resistance, as in the figure. A battery is connected between the ends of the copper rails, so the potential difference between them is 6 V, and a magnetic field of flux density 0.1 T acts perpendicular to the rod ab. What is the acceleration of the rod at the moment it starts to move? (Given: F = ma)



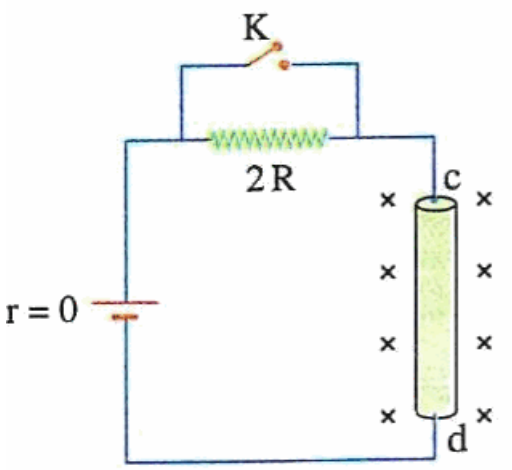
(A) 3 m/s² (B) 1.5 m/s² (C) 0.15 m/s² (D) 0.015 m/s²

29 A straight wire ab of length 1.5 m carries an electric current I and is placed perpendicular to a magnetic field of flux density 0.2 T. If the magnetic force acting on the wire is 2.4 N in the direction shown in the figure, the value and direction of the current I in the wire are .....



(A) 16 A, from b to a (B) 8 A, from b to a (C) 16 A, from a to b (D) 8 A, from a to b

30 A rod (cd) of electric resistance (R) is placed perpendicular to a uniform external magnetic field (B) and connected in an electric circuit as in the opposite figure. If the magnetic force acting on the rod due to the external field is (F_o), the magnitude of this force when switch (K) is closed becomes .....



(A) $1/3\ F_o$ (B) $1/2\ F_o$ (C) $2\ F_o$ (D) $3\ F_o$

31 Two straight wires (x) and (y) are made of the same material and have the same cross-sectional area. Wire (x) is longer than wire (y). Each of them is placed separately perpendicular to a uniform magnetic field of flux density (B). If the ends of each wire are connected to a potential difference (V), which wire is acted on by the greater magnetic force?

(A) Wire (x)

(B) Wire (y)

(C) Both wires are acted on by the same force

(D) Neither wire is acted on by a force

32 A straight metal wire of length ℓ, cross-sectional area 10 mm² and resistivity 2.8×10^{-8} Ω.m is connected to a battery of emf 3 V and negligible internal resistance, and is placed perpendicular to a magnetic field of flux density 10^{-3} Tesla. Then:

The magnetic force acting on the wire equals .....

(A) 0.53 N (B) 0.85 N (C) 1.07 N (D) 2.13 N

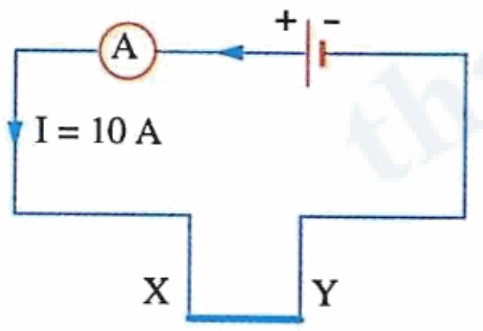
33 A straight metal wire of length ℓ, cross-sectional area 10 mm² and resistivity 2.8×10^{-8} Ω.m is connected to a battery of emf 3 V and negligible internal resistance, and is placed perpendicular to a magnetic field of flux density 10^{-3} Tesla. Then:
The force acting on the wire if its diameter is doubled equals .....

(A) 8.36 N (B) 4.28 N (C) 2.15 N (D) 1.07 N

34 A straight metal wire carrying an electric current I produces a magnetic flux of density 10^{-5} Wb/m² at a point 10 cm from it. If a magnetic field of flux density 1.5 Wb/m², inclined at 30° to the wire, acts on it, the magnetic force acting on a unit length of the wire equals .....

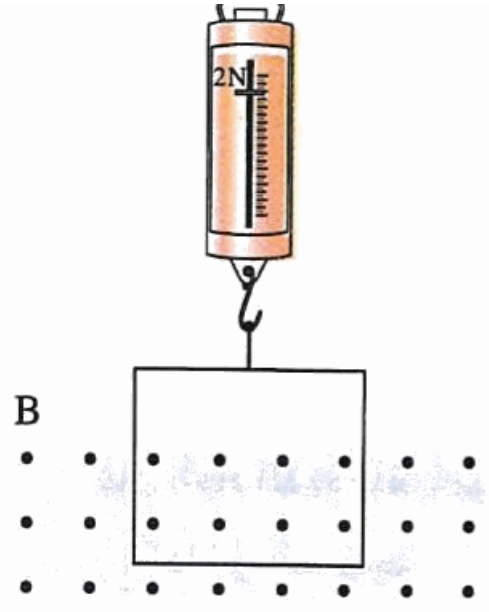
(A) 2.5 N/m (B) 5 N/m (C) 3.75 N/m (D) 10 N/m

35 An aluminium wire XY of cross-sectional area 0.1 cm² is hung horizontally while its two ends touch the ends of an electric circuit, as shown in the figure in front of you. The flux density and direction of the magnetic field that keeps the wire suspended without any other external effect are ..... (Given: $g = 10\ m/s^2$, $\rho_{Al} = 2700\ kg/m^3$)



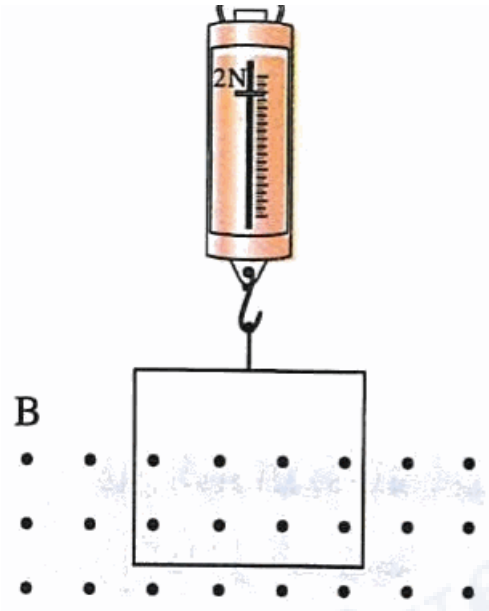
(A) 27×10^{-3} T, perpendicular out of the page
(B) 35×10^{-3} T, perpendicular out of the page
(C) 27×10^{-3} T, perpendicular into the page
(D) 35×10^{-3} T, perpendicular into the page

36 A square metal frame of side 20 cm is hung from a spring balance, and a uniform magnetic field of flux density B acts on part of it as in the opposite figure, so the balance reads 2 N. If a current of 20 A is passed through the frame anticlockwise, the balance reads 2.2 N. Then: The magnetic flux density (B) equals .....



(A) 0.1 T (B) 0.05 T (C) 0.04 T (D) 0.02 T

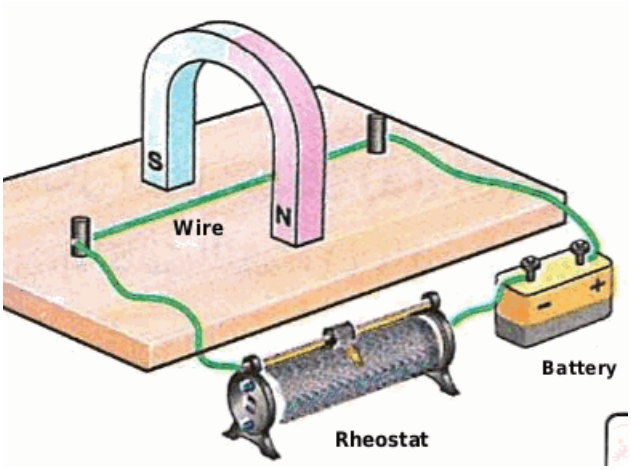
37 A square metal frame of side 20 cm is hung from a spring balance, and a uniform magnetic field of flux density B acts on part of it as in the opposite figure, so the balance reads 2 N. If a current of 20 A is passed through the frame anticlockwise, the balance reads 2.2 N. Then: The reading of the spring balance when the direction of the field is reversed equals .....



(A) 2.2 N (B) 2 N (C) 1.8 N (D) 0.2 N

38 A straight wire of weight w is placed horizontally, perpendicular to a magnetic field, as in the opposite figure. When an electric current I passes through the wire, the resultant force acting on it is 3w, vertically downward. The magnitude and direction of the resultant force acting on the wire if:

the direction of the magnetic field is reversed .....



(A) magnitude w, direction vertically upward

(B) magnitude w, direction vertically downward

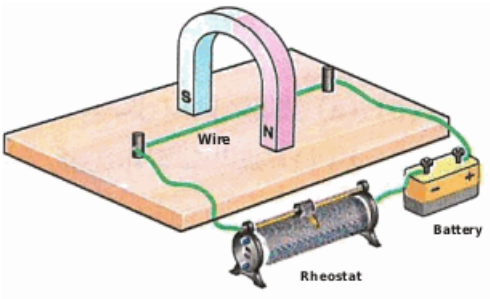
(C) magnitude 3 w, direction vertically upward

(D) magnitude 3 w, direction vertically downward

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39 A straight wire of weight w is placed horizontally, perpendicular to a magnetic field, as in the opposite figure. When an electric current I passes through the wire, the resultant force acting on it is 3w, vertically downward. The magnitude and direction of the resultant force acting on the wire if:

the current in the wire is reduced to half .....



(A) magnitude *3/2* w, direction vertically upward

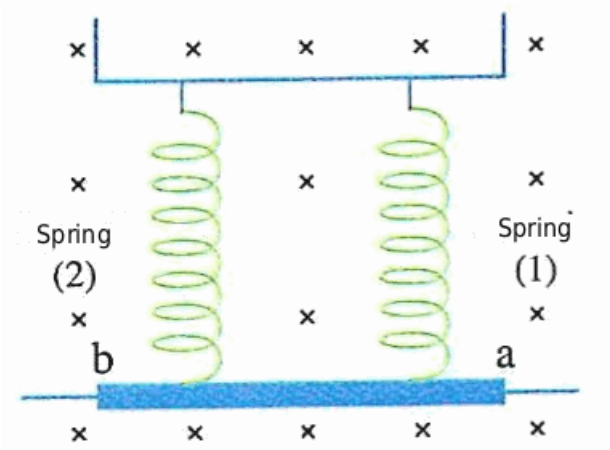
(B) magnitude *3/2* w, direction vertically downward

(C) magnitude 2 w, direction vertically upward

(D) magnitude 2 w, direction vertically downward

40 A metal rod ab of length 0.4 m and mass 50 g is hung from two identical insulated springs of negligible mass, and a magnetic field of flux density 0.2 T acts on it as in the figure. Then: (Given: acceleration due to gravity $10\ m/s^2$)

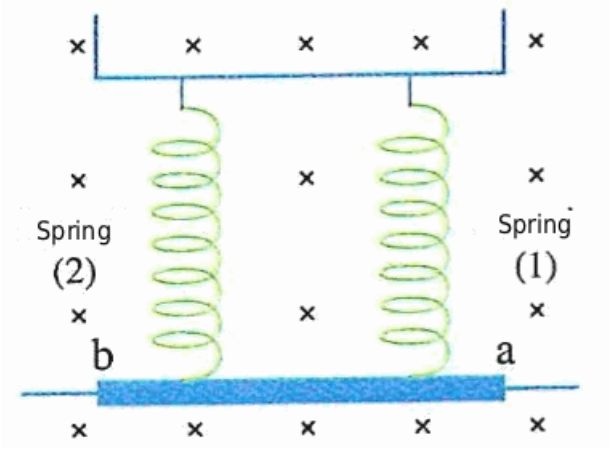
The value and direction of the electric current that, if passed through the rod, makes the tension in the springs zero are .....



(A) 6.25 A, from b to a
(B) 4.5 A, from b to a
(C) 6.25 A, from a to b
(D) 4.5 A, from a to b

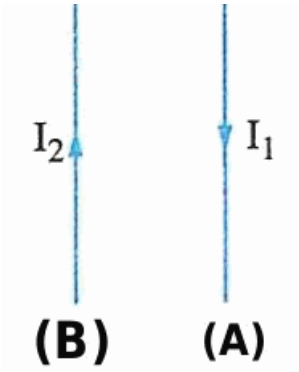
41 A metal rod ab of length 0.4 m and mass 50 g is hung from two identical insulated springs of negligible mass, and a magnetic field of flux density 0.2 T acts on it as in the figure. Then: (Given: acceleration due to gravity $10\ m/s^2$)

The tension in each spring if the direction of the current is reversed while its value stays the same is .....



(A) 0.12 N
(B) 0.25 N
(C) 0.5 N
(D) 0.7 N

42 In the opposite figure, two wires (A) and (B) carry currents I_1 and I_2 such that $I_2 < I_1$. The direction of the magnetic force acting on wire (B) is .....



(A) into the page
(B) out of the page
(C) to the left of the page
(D) to the right of the page

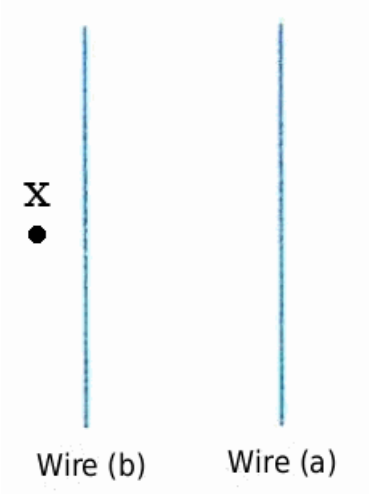
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43 The type of the mutual magnetic force between two parallel wires, each carrying an electric current, depends on .....

(A) the direction of the current in each of them
(B) the current in each of them
(C) the distance between them
(D) the length of each of them

---

44 In the opposite figure, two long straight parallel wires (a) and (b) each carry an electric current. If point (x) shown in the figure is a neutral point, then the two wires .....



(A) repel each other
(B) attract each other
(C) have no magnetic force between them
(D) carry equal electric currents

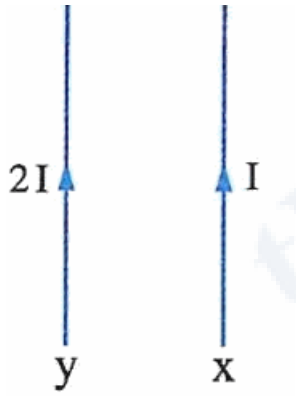
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45 Each of the following two figures (1) and (2) shows the magnetic field produced by electric currents in two long straight parallel wires placed perpendicular to the plane of the page.
In which figure is the mutual magnetic force between the two wires a force of attraction?



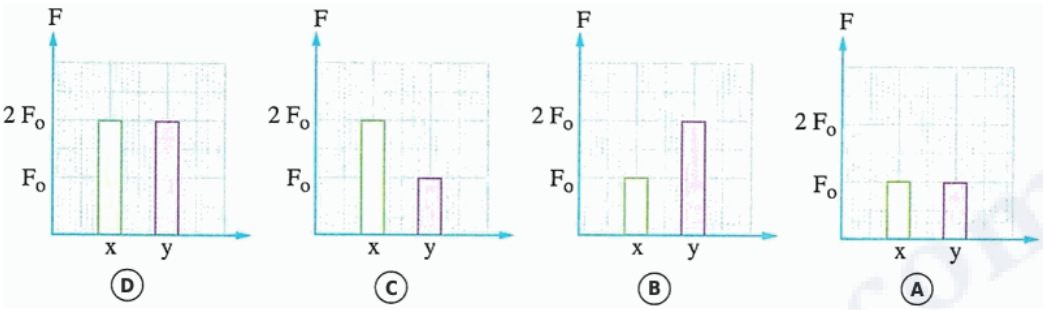
(A) In figure (1) (B) In figure (2) (C) In both figures (D) In neither figure

46 In the figure shown, the ratio of the force acting on wire x to the magnetic force acting on wire y is .....

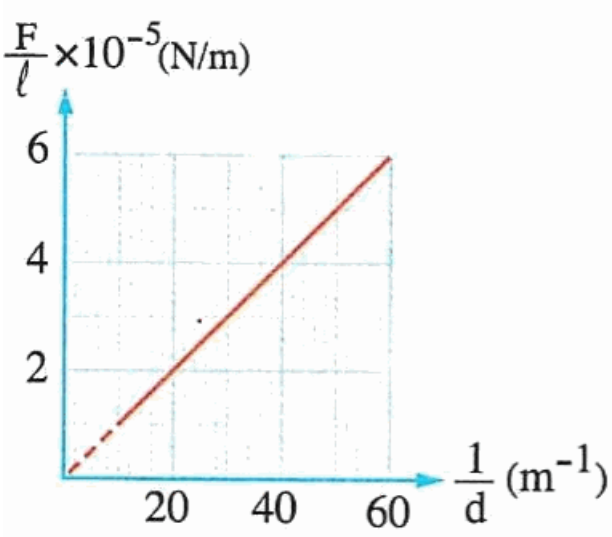


(A) *1/1* (B) *2/1* (C) *1/2* (D) *1/4*

47 Two straight parallel wires x and y each carry an electric current I, and the magnetic force acting on each of them is F_o. If the current in wire x is doubled, which of the following graphs represents the magnitudes of the magnetic force acting on each of the wires x and y?



48 The opposite graph represents the relation between the mutual magnetic force per unit length $(F/(\ell))$ between two long parallel wires and the reciprocal of the perpendicular distance between them $(1/d)$. If the currents in the two wires have the same value, the current in either of them equals .....

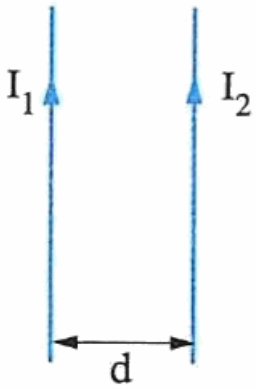


(A) 1 A (B) 1.51 A (C) 2.24 A (D) 3 A

49 Two long parallel wires a distance d apart each carry an electric current of 10 A in the same direction. If the mutual magnetic force between them per unit length is 2×10^{-4} N/m, the distance d equals .....

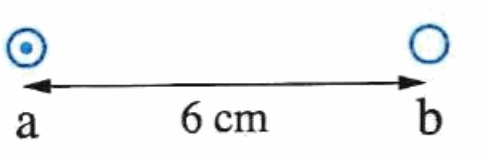
(A) 5 cm (B) 10 cm (C) 15 cm (D) 20 cm

50 In the opposite figure, two very long parallel wires each carry an electric current, and the mutual magnetic force between them is 0.01 N. If one of the currents is doubled and the distance between them is halved, the mutual magnetic force between them becomes .....



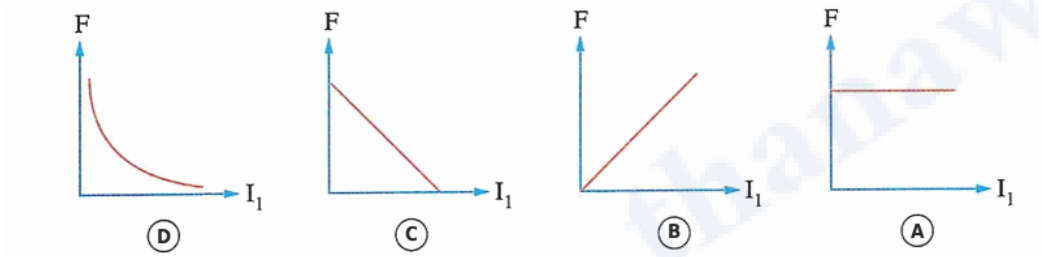
(A) 0.04 N (B) 0.02 N (C) 0.01 N (D) 0.005 N

51 The opposite figure shows two straight parallel wires a and b perpendicular to the plane of the page, 6 cm apart. Wire a carries a current of 24 A out of the page. If wire a exerts a force of attraction of 8.8×10^{-4} N/m on a unit length of wire b, the value and direction of the current in wire b are respectively .....

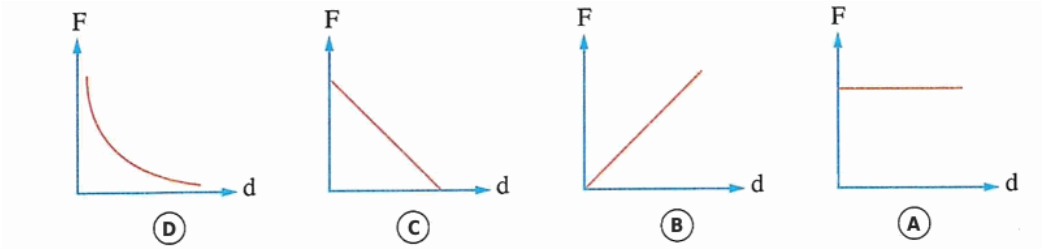


(A) 11 A, out of the page
(B) 12.5 A, out of the page
(C) 11 A, into the page
(D) 12.5 A, into the page

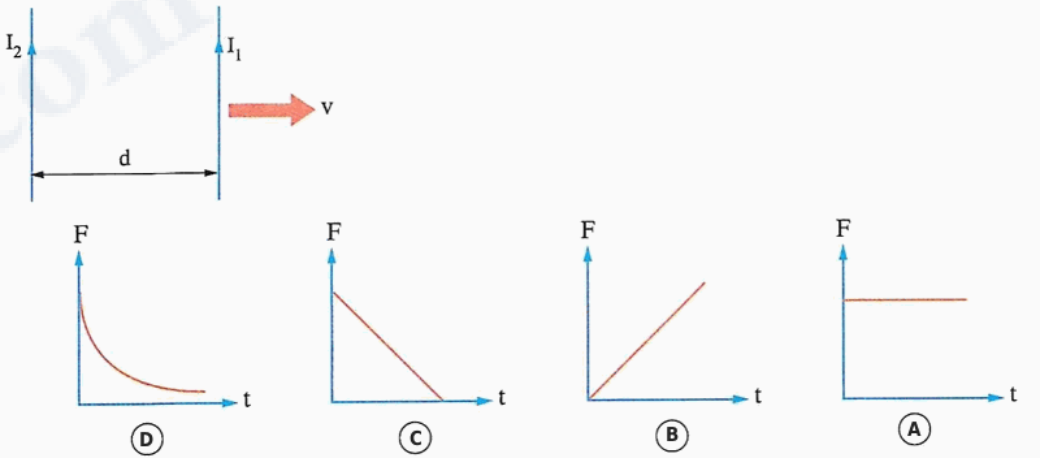
52 Which of the following graphs represents the relation between the mutual magnetic force (F) between two parallel wires, each carrying an electric current, and the current (I_1) in one of the wires, when the other factors are constant?



53 Which of the following graphs represents the relation between the mutual magnetic force (F) between two parallel wires, each carrying an electric current, and the distance (d) between them?



54 In the figure shown, if the first wire moves east at a constant speed (v), which of the following graphs represents the relation between the mutual force between the two wires (F) and time (t)?



55 A very long straight wire carries an electric current of 5 A: (Given: $(\mu)/(2\pi) = 2 \times 10^{-7}$ $Wb/A.m$)

The magnetic flux density produced by the current in the wire at a point in air at a perpendicular distance of 10 cm from the wire equals .....

(A) 1×10^{-5} T (B) 2×10^{-5} T (C) 3×10^{-5} T (D) 4×10^{-5} T

56 A very long straight wire carries an electric current of 5 A: (Given: $(\mu)/(2\pi) = 2 \times 10^{-7}$ $Wb/A.m$)

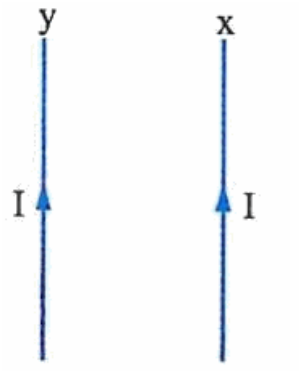
If another wire of length 50 cm, parallel to the first wire and carrying a current of 2 A, is placed at a perpendicular distance of 10 cm from it, the force acting on the second wire due to the field of the first wire equals .....

(A) 2.5×10^{-5} N (B) 1×10^{-5} N (C) 0.5×10^{-4} N (D) 0.25×10^{-4} N

57 Two straight parallel wires 2 m apart in air each carry an electric current in the same direction. If the magnetic flux density is zero at the midpoint between them and the force acting on one metre of either wire is 4×10^{-5} N, the current in each wire equals .....

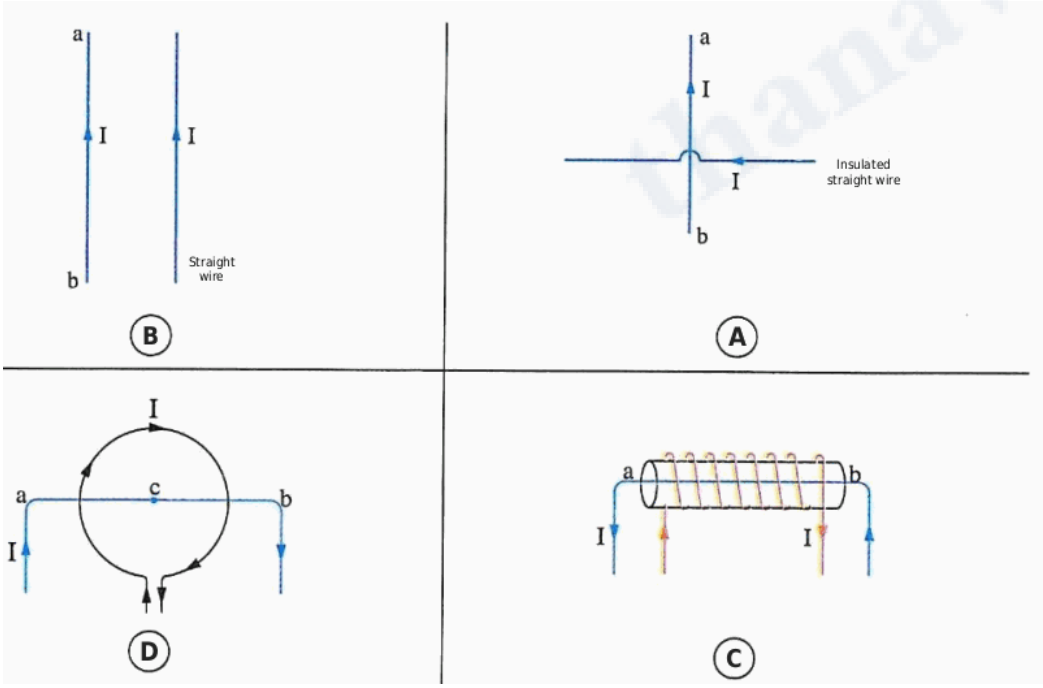
(A) 10 A, 20 A (B) 15 A, 3 A (C) 10 A, 10 A (D) 20 A, 20 A

58 In the opposite figure, two straight parallel wires x and y each carry an electric current I in the same direction, so a magnetic force (F) acts between them. If the current in wire x is increased by 4 A, the mutual force between them doubles. The value of I is .....

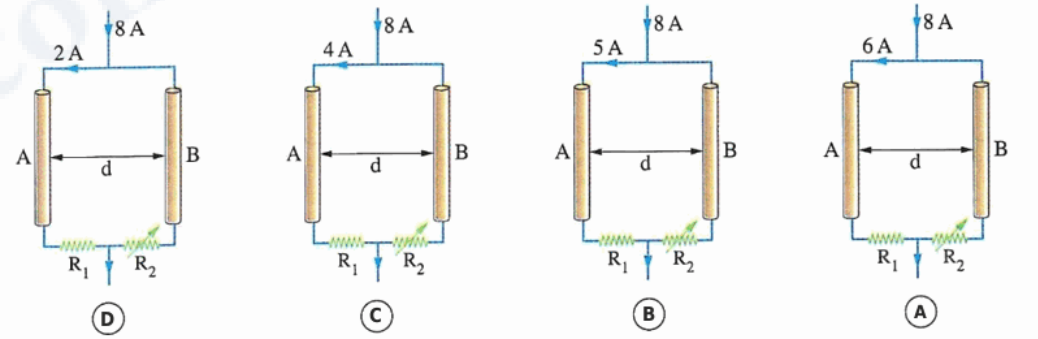


(A) 2 A (B) 4 A (C) 6 A (D) 8 A

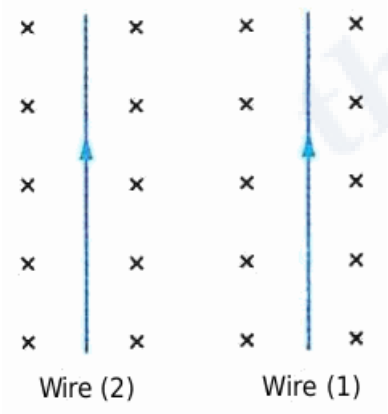
59 In which of the following cases is the insulated straight wire ab NOT acted on by a resultant magnetic force?



60 Two identical straight parallel wires A and B, a distance d apart, are included as part of an electric circuit. When the value of the rheostat R_2 is changed, the current in each of them changes as shown in the following figures. In which of these figures is the mutual force between the two wires the greatest?

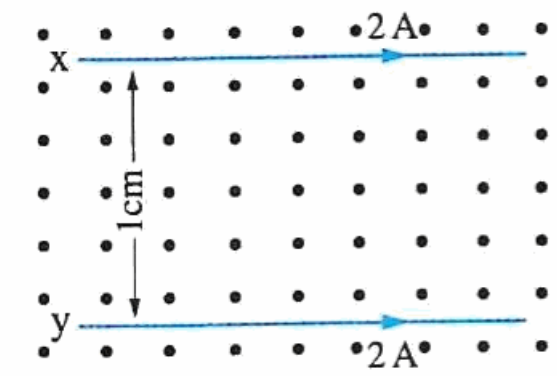


61 Two long parallel wires (1) and (2) each carry an electric current (I) and are placed perpendicular to a uniform external magnetic field, as in the opposite figure. If the resultant magnetic forces acting on a unit length of the two wires are F_1 and F_2 respectively, which of the following relations is correct?



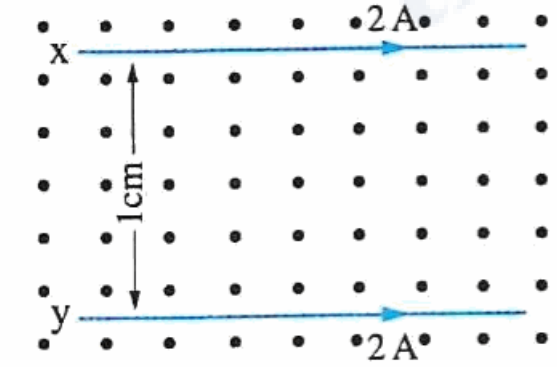
(A) $F_1 = F_2 = 0$ (B) $F_1 > F_2$ (C) $F_1 = F_2 \neq 0$ (D) $F_1 < F_2$

62 Two long parallel wires x and y each carry an electric current of 2 A and are placed in a uniform external magnetic field of flux density 2×10^{-5} T perpendicular to each of them. The total magnetic force acting on a unit length of:
wire (x) equals .....



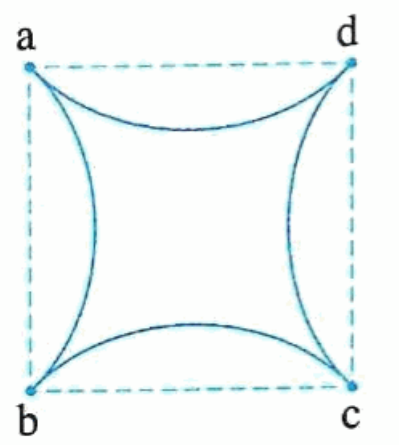
(A) 1.2×10^{-5} N/m (B) 4×10^{-5} N/m (C) 8×10^{-5} N/m (D) 1.2×10^{-4} N/m

63 Two long parallel wires x and y each carry an electric current of 2 A and are placed in a uniform external magnetic field of flux density 2×10^{-5} T perpendicular to each of them. The total magnetic force acting on a unit length of:
wire (y) equals .....



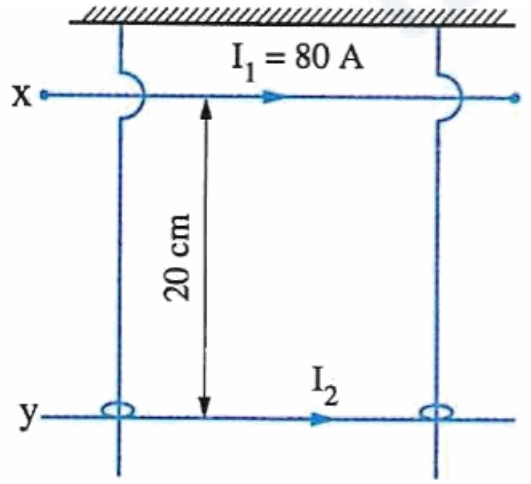
(A) 1.2×10^{-5} N/m (B) 4×10^{-5} N/m (C) 8×10^{-5} N/m (D) 1.2×10^{-4} N/m

64 A flexible uninsulated metal wire is shaped into a square frame abcd. Between which two points of the frame must a DC source be connected so that its wires take the position shown in the opposite figure?



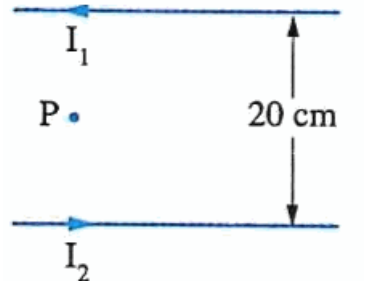
(A) a, b (B) a, d (C) d, c (D) d, b

65 The opposite figure shows two horizontal straight wires x and y in the same plane. Wire x is fixed and carries a current of 80 A, and wire y, 20 cm from it, can move up and down. If the mass of one metre of wire y is 0.12 g/m, the current (I_2) that must pass through it so that it stays suspended and does not fall under gravity is ..... (Given: $g = 10\ m/s^2$)



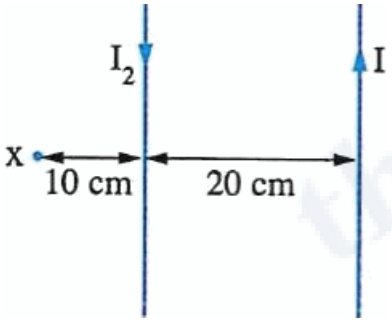
(A) 15 A (B) 20 A (C) 30 A (D) 40 A

66 Two straight parallel wires, each 50 cm long and 20 cm apart in air. The first wire carries a current I_1 and the second a current $I_2 = 10$ A in the direction shown in the opposite figure. If the total flux density at point P, midway between the two wires, is 6×10^{-5} T, the mutual magnetic force between them equals .....



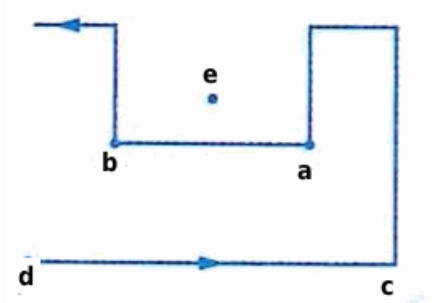
(A) 10^{-2} N (B) 10^{-3} N (C) 10^{-4} N (D) 10^{-5} N

67 In the figure shown, if point x is the neutral point and the magnetic force acting on one metre of either wire is 12×10^{-6} N, the two currents I_1 and I_2 respectively equal .....



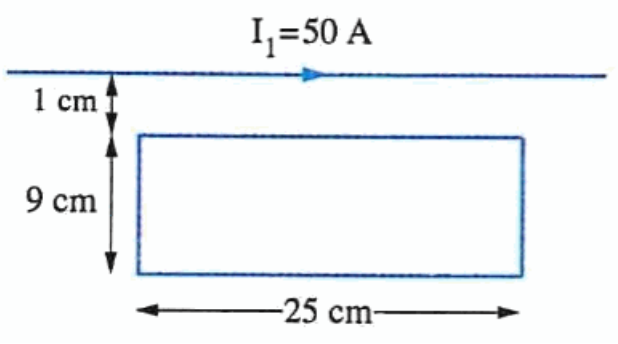
(A) $I_1 = 3$ A, $I_2 = 1$ A (B) $I_1 = 1$ A, $I_2 = 1$ A
(C) $I_1 = 6$ A, $I_2 = 4$ A (D) $I_1 = 6$ A, $I_2 = 2$ A

68 Two horizontal wires ab and cd lie in the same vertical plane and each carries a current of 50 A. Wire ab is 1 m long, has a mass of 5 g and is free to move vertically, while wire cd is fixed. If wire ab is in equilibrium as shown in the figure, and neglecting the flux density produced by the vertical wires, the distance between the two wires equals ..... (Given: $g = 10\ m/s^2$)



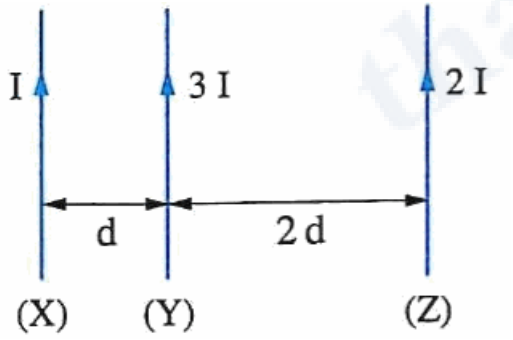
(A) 0.23 m (B) 0.15 m (C) 0.02 m (D) 0.01 m

69 The figure shows a rectangular frame of thin wire of dimensions 25 cm and 9 cm and mass 4.5 g. Above it, in the same plane, is a long horizontal straight wire carrying an electric current of 50 A. The value and direction of the current that must pass through the frame so that it stays suspended vertically in the air are ..... (Given: $g = 10\ m/s^2$)



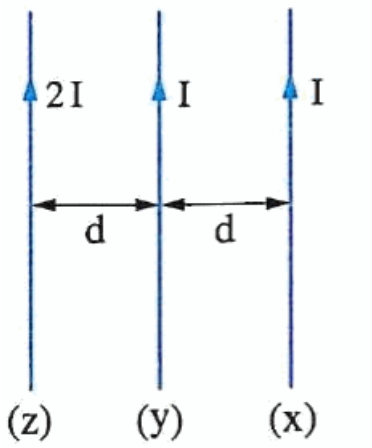
(A) 200 A, anticlockwise
(B) 200 A, clockwise
(C) 100 A, anticlockwise
(D) 100 A, clockwise

70 In the opposite figure, three long parallel wires carry electric currents. Which wire is NOT acted on by a resultant magnetic force?



(A) Z
(B) Y
(C) X
(D) Z and X together

71 Three long straight parallel wires (x), (y) and (z) carry currents in the same direction of I, I and 2I respectively, as in the opposite figure. Which wire is acted on by the greatest resultant magnetic force?



(A) Wire (x)

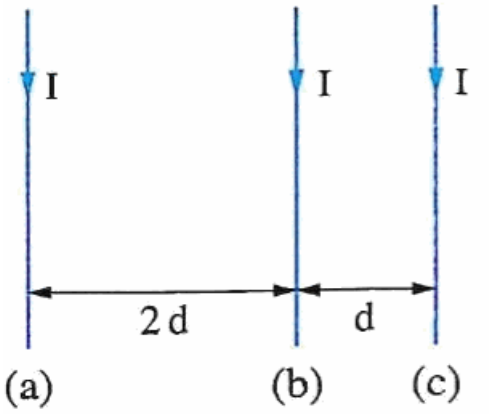
(B) Wire (y)

(C) Wire (z)

(D) The three wires are acted on by the same force

---

72 In the opposite figure, three long parallel wires (a), (b) and (c) in the plane of the page carry currents of the same value in the directions shown. The direction of the resultant magnetic force acting on wire (b) is .....



(A) perpendicular to the plane of the page, inward

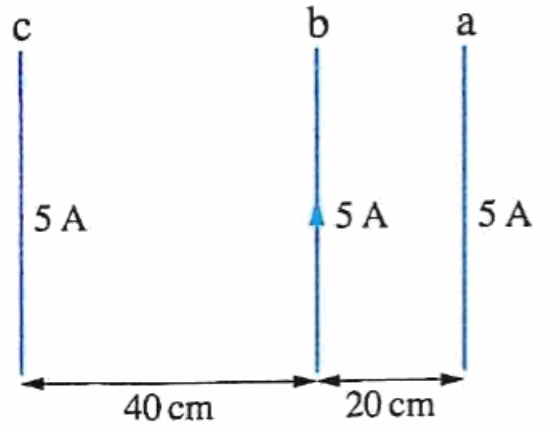
(B) perpendicular to the plane of the page, outward

(C) in the plane of the page, to the right

(D) in the plane of the page, to the left

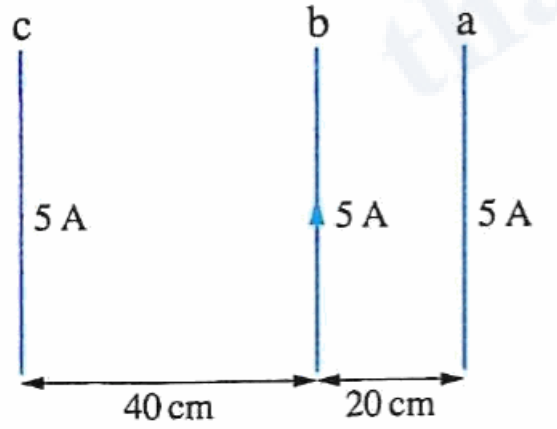
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73 In the opposite figure, three parallel wires in one plane each carry an electric current of 5 A.
The force acting on one metre of wire b when the currents in wires a and c are:
in the same direction equals .....



(A) 50×10^{-6} N (B) 37.5×10^{-6} N (C) 25×10^{-6} N (D) 12.5×10^{-6} N

74 In the opposite figure, three parallel wires in one plane each carry an electric current of 5 A.
The force acting on one metre of wire b when the currents in wires a and c are:
in opposite directions equals .....



(A) 75×10^{-6} N (B) 37.5×10^{-6} N (C) 19×10^{-6} N (D) 14×10^{-6} N

75 Two straight parallel wires 10 cm apart, one carrying a current of 2 A and the other 3 A in the same direction:
The distance of the neutral point from the wire carrying 2 A equals .....

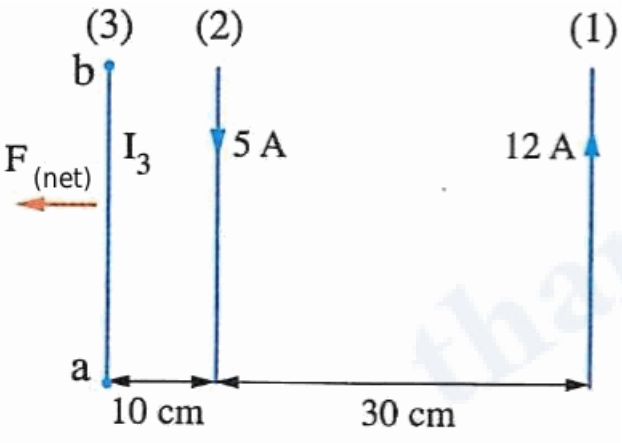
(A) 2.5 cm (B) 4 cm (C) 6.5 cm (D) 8 cm

76 Two straight parallel wires 10 cm apart, one carrying a current of 2 A and the other 3 A in the same direction:

If the current in one of the wires is reversed, and a third wire of length 10 cm carrying a current of 5 A is placed parallel to them, in the same plane, at the previous neutral point, the force acting on it equals .....

(A) 7.3×10^{-5} N (B) 5×10^{-5} N (C) 2.5×10^{-5} N (D) 10^{-5} N

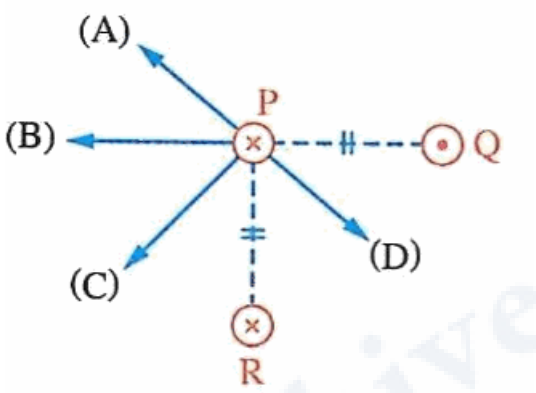
77 The opposite figure shows three long straight wires in the plane of the page, each carrying an electric current. If the resultant magnetic force acting on a unit length of wire (3) is 3×10^{-6} N/m, in the plane of the page to the left, the value and direction of the current in wire (3) are .....



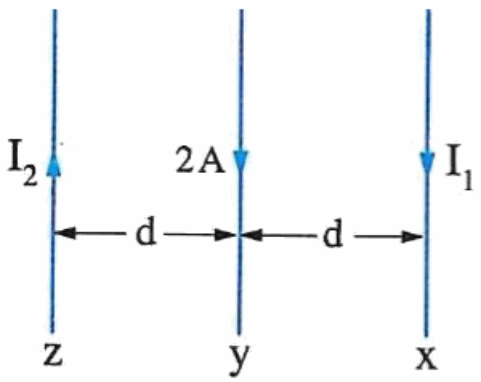
(A) 0.75 A, from b to a (B) 0.75 A, from a to b

(C) 5 A, from b to a (D) 5 A, from a to b

78 The opposite figure shows three long wires P, Q and R perpendicular to the page, each carrying the same current. If the currents in wires P and R are into the page while the current in wire Q is out of the page, which of the directions shown (A, B, C, D) represents the direction of the force acting on wire P?

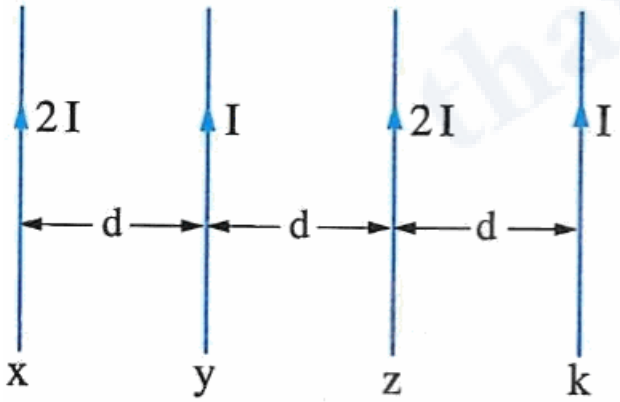


79 In the figure shown, three straight parallel wires in one plane each carry an electric current. If the magnetic force acting on one metre of wire y is F, and when the current in wire x is reversed the force acting on a unit length of wire y becomes *1/2* F, the ratio between the two currents (I_1/I_2) equals ..... (Given: $I_2 < I_1$)



(A) *2/1* (B) *3/1* (C) *4/1* (D) *5/4*

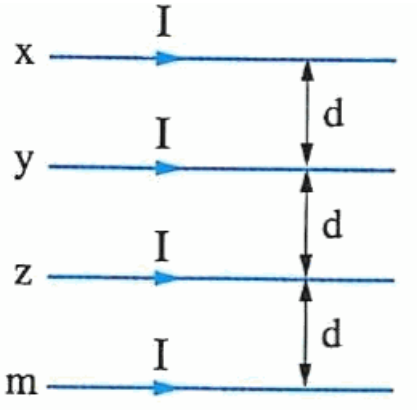
80 Four straight parallel wires (x), (y), (z) and (k) each carry an electric current as shown in the opposite figure. The magnetic force acting on a unit length of wire (z) equals .....



(A) $1/2 \times (\mu I^2)/(\pi d)$ (B) $(\mu I^2)/(\pi d)$

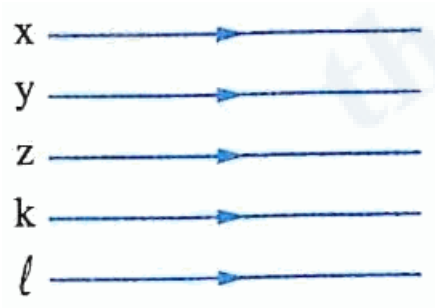
(C) $2 \times (\mu I^2)/(\pi d)$ (D) $4 \times (\mu I^2)/(\pi d)$

81 The opposite figure shows four identical parallel wires x, y, z and m, each carrying an electric current I in the same direction. If the resultant magnetic force acting on wire z equals F, the resultant magnetic force acting on wire m equals .....



(A) *11/3* F (B) *11/6* F (C) *11/5* F (D) *11/2* F

82 Five straight parallel wires x, y, z, k and ℓ, equally spaced, each carry an electric current I as in the opposite figure. The correct order of the wires according to the magnetic force acting on each of them is .....

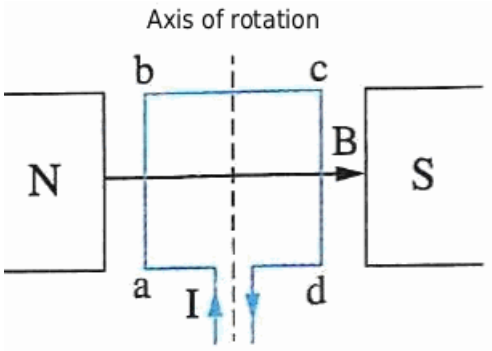


(A) $z > x = \ell > y = k$ (B) $y = k > x = \ell > z$ (C) $x = \ell > z > y = k$ (D) $x = \ell > y = k > z$

83 The torque (τ) acting on a coil carrying an electric current placed in a uniform magnetic field is maximum when the plane of the coil is ..... the direction of the magnetic field.

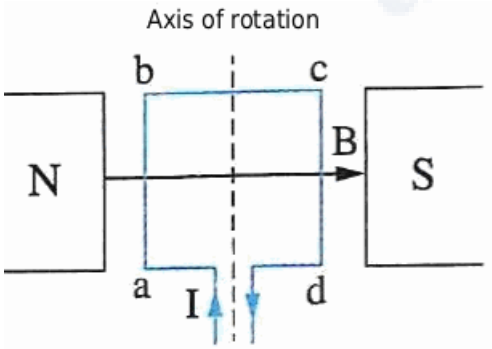
(A) perpendicular to (B) parallel to (C) inclined at 30° to (D) inclined at 60° to

84 A square coil abcd carrying an electric current (I) is placed in a magnetic field of flux density B as in the opposite figure. What happens, while the coil rotates a quarter of a turn from the position shown in the figure, to:
the magnetic force acting on side ab?



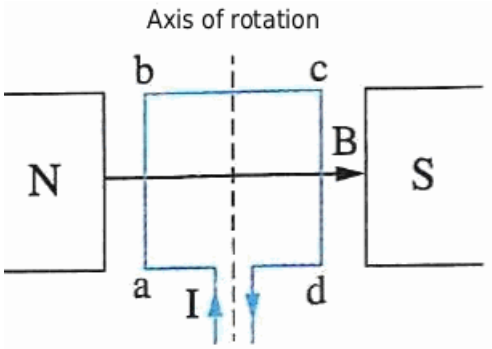
(A) It increases
(B) It decreases but does not become zero
(C) It decreases until it becomes zero
(D) It does not change

85 A square coil abcd carrying an electric current (I) is placed in a magnetic field of flux density B as in the opposite figure. What happens, while the coil rotates a quarter of a turn from the position shown in the figure, to:
the magnetic force acting on side bc?



(A) It increases
(B) It decreases but does not become zero
(C) It decreases until it becomes zero
(D) It does not change

86 A square coil abcd carrying an electric current (I) is placed in a magnetic field of flux density B as in the opposite figure. What happens, while the coil rotates a quarter of a turn from the position shown in the figure, to:
the magnetic torque acting on the coil?



(A) It increases
(B) It decreases but does not become zero
(C) It decreases until it becomes zero
(D) It does not change

---

87 A coil of 200 turns, each of area 300 cm², is placed parallel to a magnetic field of flux density 0.4 T, and it is acted on by a torque of 20 N.m. The current in the coil equals .....

(A) 4.37 A
(B) 8.33 A
(C) 11.53 A
(D) 13.98 A

---

88 A coil of 500 turns, each of area 0.2 m², carries a current of 10 A and is placed in a magnetic field of flux density 0.25 Tesla. The torque acting on it when the angle between the normal to the coil and the direction of the field is 30° equals .....

(A) 50 N.m
(B) 75 N.m
(C) 110 N.m
(D) 125 N.m

---

89 A rectangular coil of dimensions 20 cm and 10 cm with 200 turns is placed in a uniform magnetic field of flux density 0.4 Tesla and carries an electric current of 3 A. The torque acting on the coil when:
the plane of the coil is inclined at 60° to the direction of the field equals .....

(A) 0
(B) 2.4 N.m
(C) 3.6 N.m
(D) 4.5 N.m

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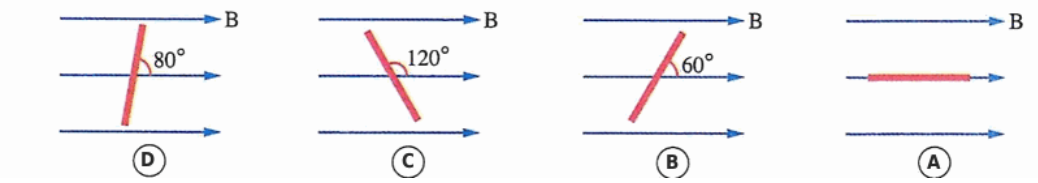
90 A rectangular coil of dimensions 20 cm and 10 cm with 200 turns is placed in a uniform magnetic field of flux density 0.4 Tesla and carries an electric current of 3 A. The torque acting on the coil when:
the plane of the coil is perpendicular to the direction of the field equals .....

(A) 6.2 N.m
(B) 4.8 N.m
(C) 2.5 N.m
(D) 0

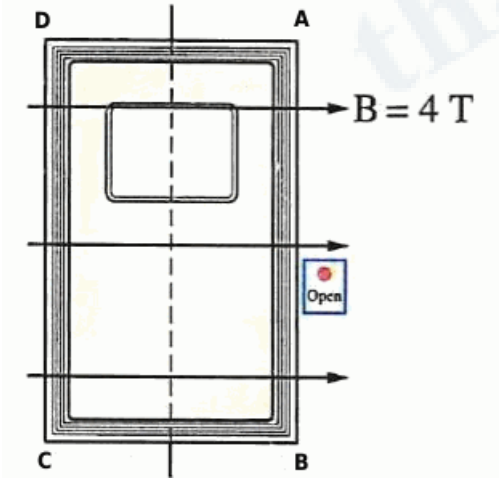
91 A rectangular coil of dimensions 20 cm and 10 cm with 200 turns is placed in a uniform magnetic field of flux density 0.4 Tesla and carries an electric current of 3 A. The torque acting on the coil when:
the plane of the coil is parallel to the field equals .....

(A) 7.4 N.m (B) 0 (C) 4.8 N.m (D) 5.3 N.m

92 In which of the following positions of a coil carrying an electric current placed in a uniform magnetic field is the torque smallest?

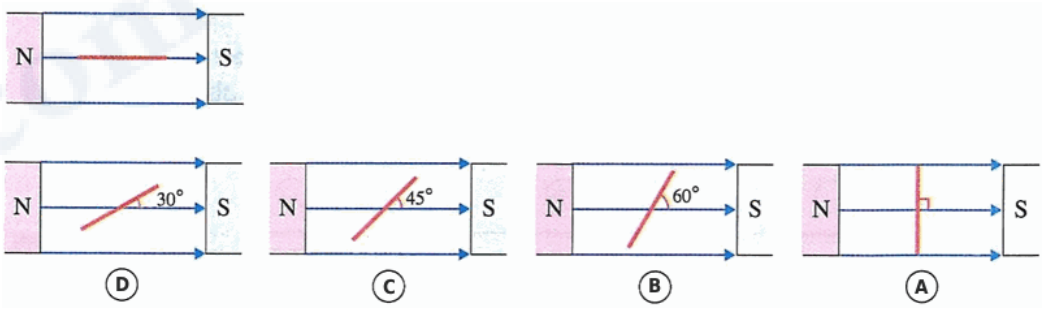


93 An inventor wants to design an automatic door ABCD of area 2 m^2 with a coil of 50 turns wound around it as in the figure, so that the door starts to rotate about its axis under a torque of 400 N.m from the position shown, with side AB moving out of the page. The value and direction of the current in side AB are .....

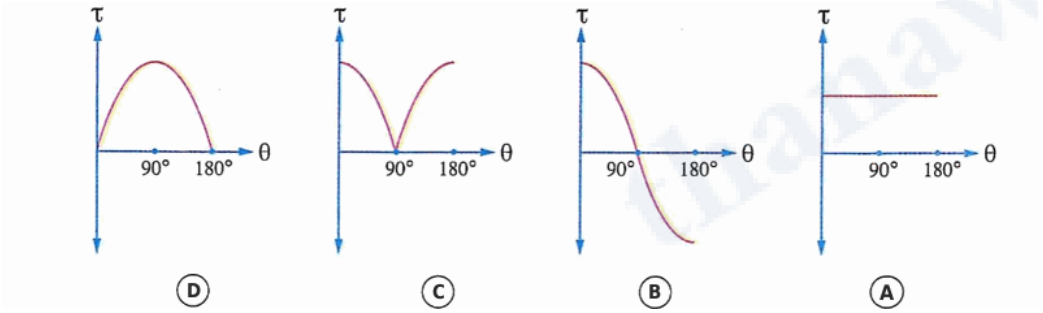


(A) 1 A, from A to B (B) 0.5 A, from A to B
(C) 1 A, from B to A (D) 0.5 A, from B to A

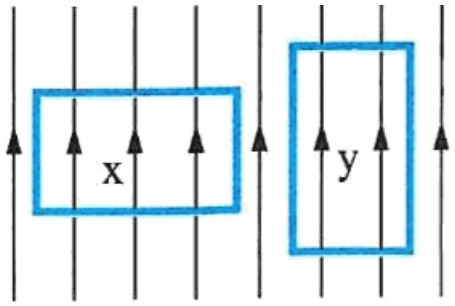
94 The opposite figure shows a side view of a rectangular coil carrying an electric current, placed in a magnetic field and acted on by a torque (τ). Which of the following positions of the coil makes it acted on by a torque $= (\tau)/2$?



95 Which of the following graphs represents the relation between the torque (τ) acting on a coil carrying an electric current placed in a uniform magnetic field and the angle (θ) between the plane of the coil and the normal to the field during half a turn, when the coil starts rotating from the position perpendicular to the field?

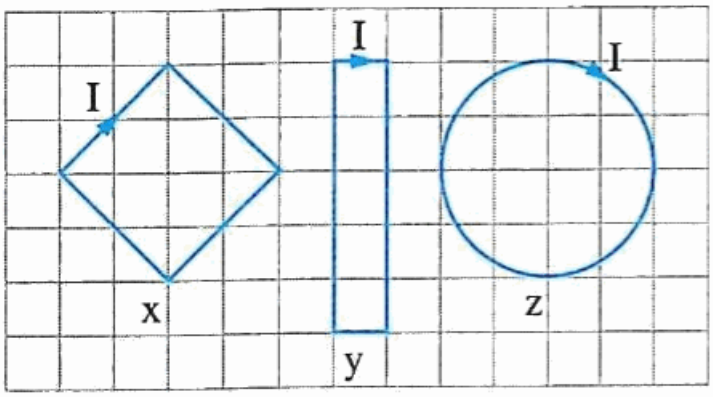


96 The opposite figure shows two identical frames x and y, each of dimensions ℓ and 2ℓ, placed in a uniform magnetic field. The ratio of the torques acting on the two frames $((\tau_x)/(\tau_y))$ if the same electric current passes through them equals .....



(A) 1/2 (B) 2/1 (C) 3/1 (D) 1/1

97 Three coils x, y and z, each of one turn, differ in shape, and their dimensions are shown by the opposite grid. If the planes of these coils are parallel to a uniform magnetic field of flux density B and each carries an electric current (I), the correct order of the magnetic torques acting on them is .....

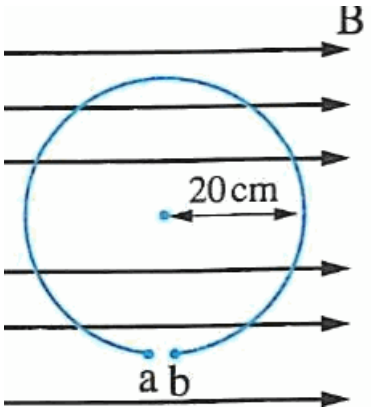


(A) $\tau_x > \tau_y > \tau_z$ (B) $\tau_x > \tau_z > \tau_y$ (C) $\tau_z > \tau_y > \tau_x$ (D) $\tau_z > \tau_x > \tau_y$

98 A rectangular coil of 50 turns has a magnetic flux of maximum value 0.2 Wb passing through it. The maximum torque that can act on the coil when it carries a current of 2 A equals .....

(A) 20 N.m (B) 40 N.m (C) 60 N.m (D) 80 N.m

99 In the opposite figure, a metal ring in the shape of an almost complete circle has a wire resistance of 0.1 Ω. If a battery of emf 9 V and negligible internal resistance is connected between points a and b, the magnetic torque acting on the ring due to a uniform magnetic field (B) of flux density 0.4 T in the plane of the ring equals ..... (Given: $\pi = 3.14$)

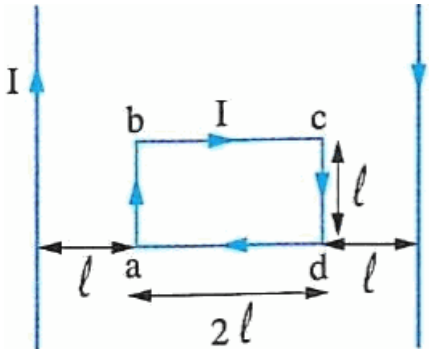


(A) 2.35 N.m (B) 3.75 N.m (C) 3.92 N.m (D) 4.52 N.m

100 A battery of emf 14 V and negligible internal resistance is connected to a circular coil of radius 10 cm. If the resistivity of the coil wire's material is 7×10^{-7} Ω.m and the radius of the wire is 1 mm, the torque acting on the coil when it is placed in a magnetic field parallel to its plane with flux density 0.5 T equals ..... (Given: π = 3.14)

(A) 0.53 N.m (B) 0.61 N.m (C) 0.93 N.m (D) 1.57 N.m

101 A rectangular metal frame abcd is placed between two long straight parallel wires, all in the same plane, as in the figure. If each of them carries a current I, the coil .....



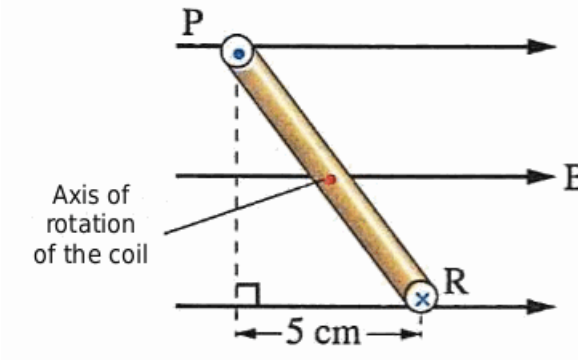
(A) rotates about an axis parallel to the two wires

(B) rotates about an axis perpendicular to the two wires

(C) moves upward in a direction parallel to the two wires

(D) is not acted on by a torque

102 The opposite figure shows a front view of a rectangular coil carrying an electric current out of the page at point P and into the page at point R. If the length of side PR of the coil, perpendicular to the axis of rotation, is 10 cm, what is the torque acting on the coil in this position relative to the maximum torque (τ_o)?



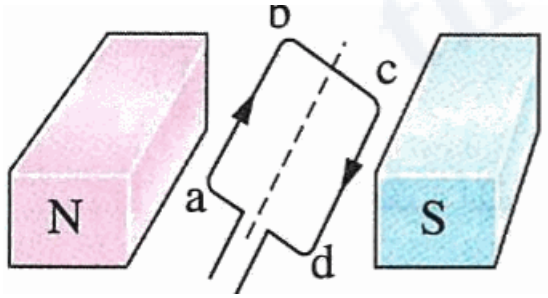
(A) $\sqrt{(2)}\ \tau_o$ (B) $1/(\sqrt{(2)})\ \tau_o$ (C) $(\sqrt{(3)})/2\ \tau_o$ (D) $1/2\ \tau_o$

103 Two coils (x) and (y) each carry an electric current and are placed in a uniform magnetic field (B) as in the following two figures (1) and (2).
For which coil does the magnetic torque acting on it become zero after it rotates 60° about the axis shown in the figure?



(A) Coil (x) only (B) Both coils (C) Coil (y) only (D) Neither coil

104 The opposite figure shows a coil abcd of dimensions 5 cm and 10 cm and one turn, carrying an electric current and placed in a uniform magnetic field. If the plane of the coil is inclined at 60° to the direction of the field and the magnetic force acting on side (bc) in the position shown is 0.5 N, the magnetic torque acting on the coil in this position is approximately .....



(A) 0.01 N.m (B) 0.02 N.m (C) 0.03 N.m (D) 0.05 N.m

105 The magnetic torque acting on a coil carrying an electric current and rotating in a uniform magnetic field becomes zero when the direction of the magnetic dipole moment of the coil is .....

(A) parallel to the direction of the field
(B) perpendicular to the direction of the field
(C) inclined at 45° to the direction of the field
(D) inclined at 135° to the direction of the field

106 A straight wire of length 32 cm is wound into a square coil of one turn, and wound again into a square coil of 4 identical turns. If the same current passes through the coil in both cases, the magnetic dipole moment of the coil in the first case is ..... that in the second case.

(A) four times (B) twice (C) half (D) a quarter of

107 A rectangular coil carrying an electric current I is placed perpendicular to a magnetic flux of density B. The magnetic dipole moment of the coil increases when .....

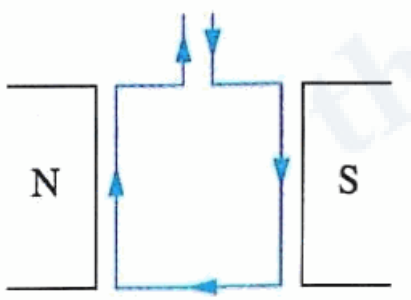
(A) the plane of the coil becomes parallel to the direction of the magnetic flux

(B) the magnetic flux density (B) increases

(C) the current in the coil (I) increases

(D) the magnetic flux (φ_m) through the coil increases

108 The opposite figure shows a rectangular metal frame carrying an electric current, placed parallel to a uniform magnetic field. The direction of the magnetic dipole moment of the coil is .....



(A) in the plane of the page, to the right (B) in the plane of the page, to the left

(C) perpendicular to the page, inward (D) perpendicular to the page, outward

109 A coil of face area 0.001 m² carries a current of 10 A and is placed in a magnetic field of flux density 2 T so that it is inclined at 60° to the field, and the torque acting on it is 1 N.m. Then: The number of turns of the coil equals ..... turns.

(A) 15 (B) 50 (C) 100 (D) 200

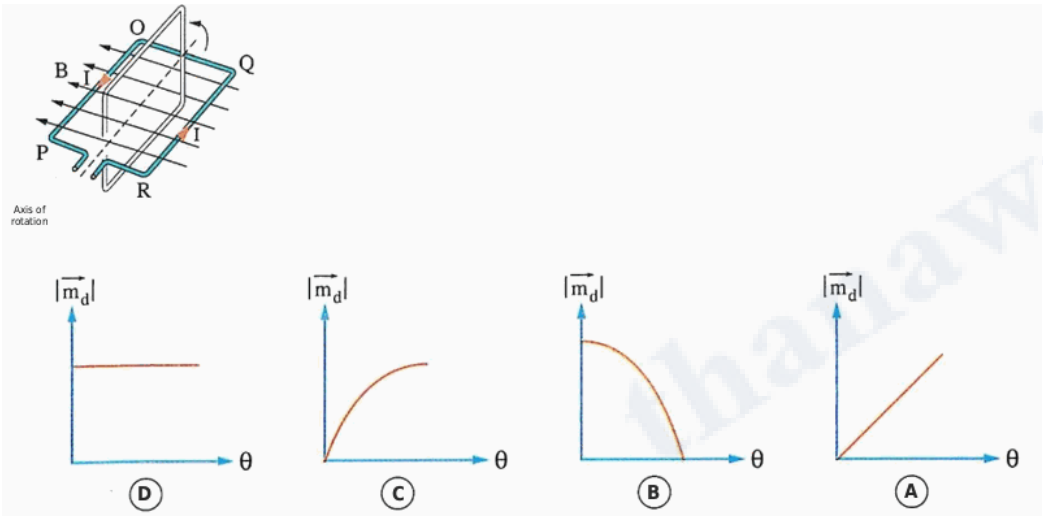
110 A coil of face area 0.001 m² carries a current of 10 A and is placed in a magnetic field of flux density 2 T so that it is inclined at 60° to the field, and the torque acting on it is 1 N.m. Then: The maximum torque acting on the coil is .....

(A) 2 N.m (B) 1.5 N.m (C) 1 N.m (D) 0.5 N.m

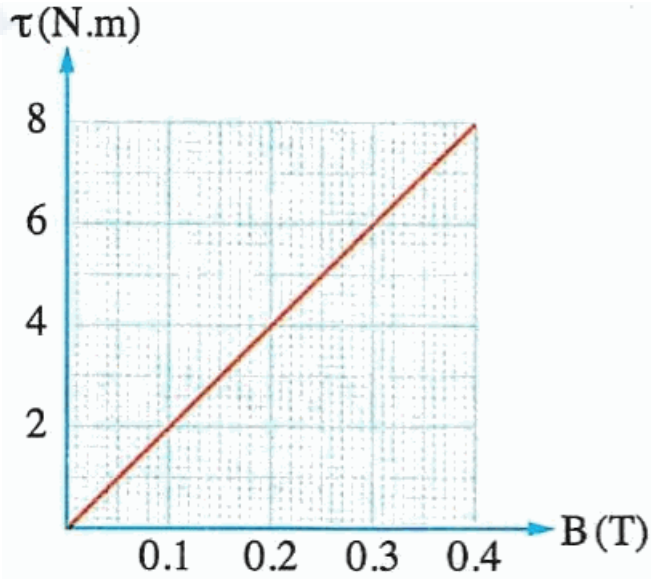
111 A coil of face area 0.001 m² carries a current of 10 A and is placed in a magnetic field of flux density 2 T so that it is inclined at 60° to the field, and the torque acting on it is 1 N.m. Then: The magnetic dipole moment of the coil equals .....

(A) 2 A.m² (B) 1.5 A.m² (C) 1 A.m² (D) 0.5 A.m²

112 The opposite figure shows a rectangular coil (POQR) of N turns carrying an electric current I, placed in a uniform magnetic field of flux density B so that the plane of the coil is parallel to the magnetic flux lines. Which of the following graphs represents the change in the magnetic dipole moment $|m_d|$ of the coil, as it rotates 90° from this position, with the angle of rotation (θ)?

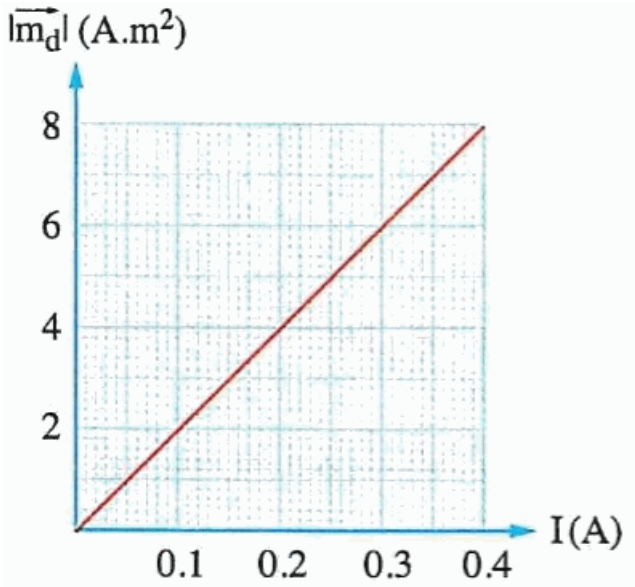


113 The opposite graph represents the relation between the torque (τ) acting on a rectangular coil carrying an electric current and the flux density (B) of a magnetic field parallel to the plane of the coil. The magnetic dipole moment of the coil equals .....



(A) 10 A.m² (B) 15 A.m² (C) 20 A.m² (D) 40 A.m²

114 A coil of 50 turns carries an electric current and rotates in a uniform magnetic field of flux density (B). The opposite graph represents the change in the magnetic dipole moment $|m_d|$ of the coil with the current (I) in it. If the maximum magnetic flux through the coil during its rotation is 0.2 Wb, the magnetic flux density (B) in which the coil is placed equals .....



(A) 0.5 T (B) 1 T (C) 1.5 T (D) 2 T

115 A circular coil of N turns and radius 10 cm carries an electric current I, producing a magnetic flux of density 2×10^{-4} T at its centre. Its magnetic dipole moment is .....

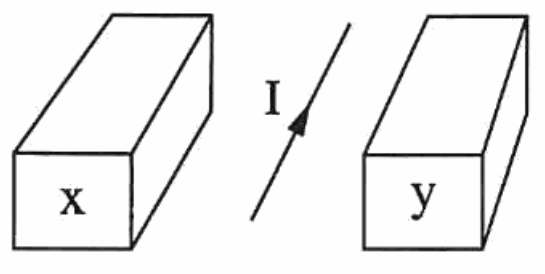
(A) 1 A.m² (B) 2 A.m² (C) 3 A.m² (D) 4 A.m²

116 A circular coil of face area 3.14 cm² carries an electric current I, and the magnetic flux density at its centre is 2×10^{-5} T. Its dipole moment equals ..... (Given: $\pi = 3.14$)

(A) 10^{-2} A.m² (B) 10^{-4} A.m² (C) 10^{-6} A.m² (D) 10^{-8} A.m²

Essay questions — 22 questions

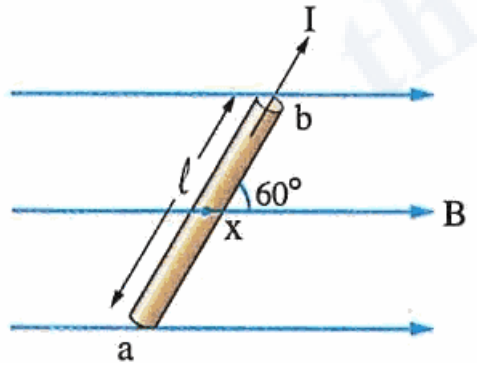
1 A straight wire, free to move, is placed horizontally between the two poles x and y of a magnet and carries an electric current I as shown in the figure. The wire was observed to move vertically downward. Determine, with explanation, the type of the magnetic pole x.



2 In the opposite figure, the straight wire ab is acted on by a magnetic force of 0.1 N. Calculate the magnetic force acting on the wire if it is rotated in the plane of the page about the axis x through an angle of 30°:

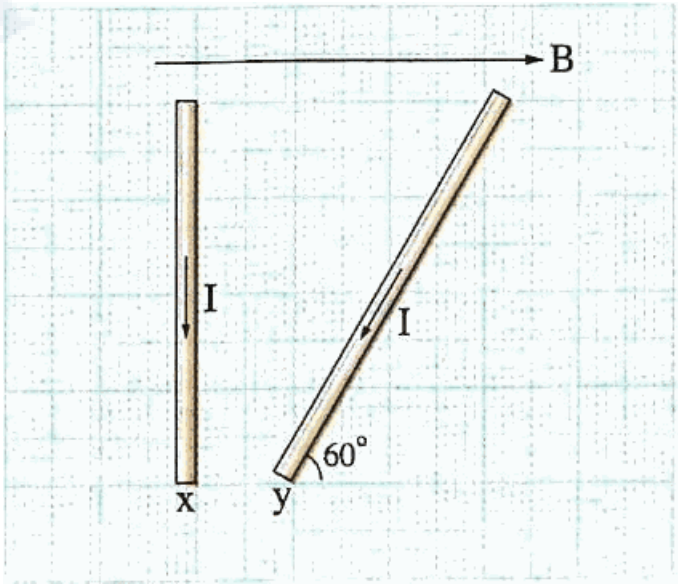
(1) clockwise.

(2) anticlockwise.

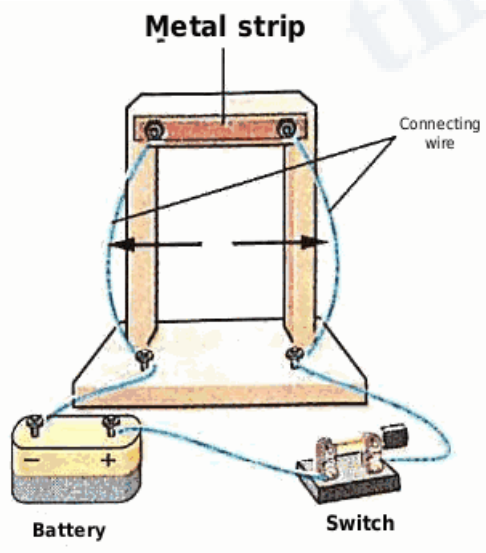


3 A straight wire whose resistance per metre is *1* Ω is connected to a DC source of emf 2 V and negligible internal resistance, and is placed perpendicular to a magnetic field (B) of flux density 0.1 T. Calculate the magnetic force acting on the wire due to the magnetic field (B).

4 In the opposite figure, two straight wires x and y each carry an electric current I and are placed in a magnetic field of flux density B in the common plane of the two wires. Find the ratio between the magnetic forces acting on them (F_x/F_y).



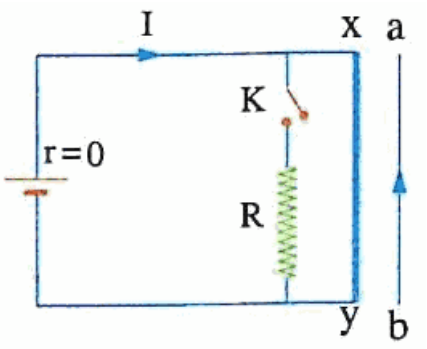
5 In the experiment in front of you, the two connecting wires bend outward when an electric current passes through them. Explain this observation.



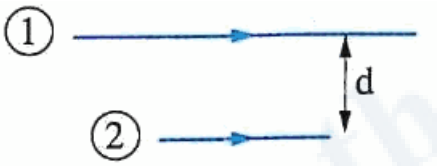
6 In the opposite figure, if the resistance of wire xy is R and the current in the circuit is I:

(1) What is the type of the mutual magnetic force between the two wires xy and ab?

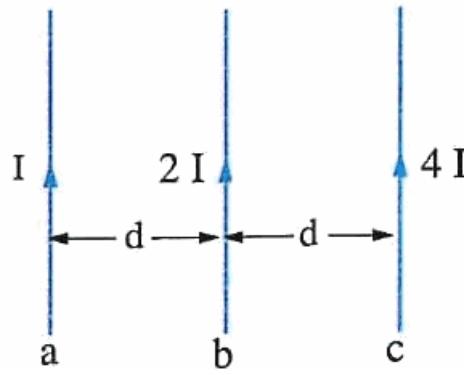
(2) When switch K is closed, what happens to the magnitude of this force?



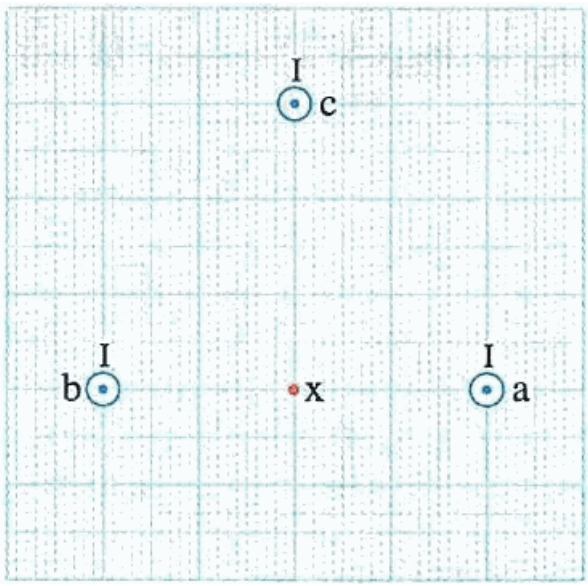
7 In the figure shown, two straight parallel wires (1) and (2) of lengths ℓ and $(\ell)/2$ respectively each carry an electric current I. If the magnetic force acting on a unit length of wire (2) is 0.2 N/m, explain what happens to this force when wire (1) is replaced by another wire of length 2ℓ carrying the same current, with the distance between the wires unchanged.



8 Three straight parallel wires a, b and c in one plane each carry an electric current as in the opposite figure. Prove that the wire acted on by the greatest magnetic force per unit length is wire c.



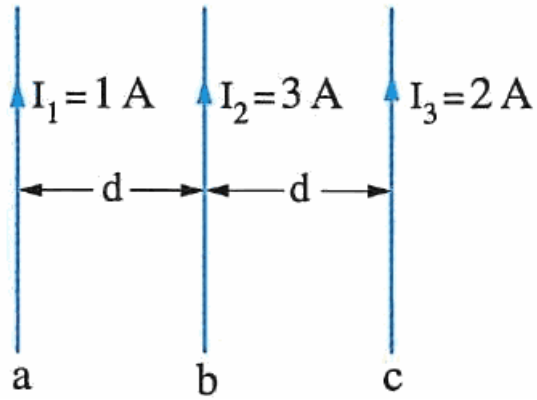
9 In the opposite figure, three straight vertical wires a, b and c each carry an electric current I. Explain what happens to the magnetic force acting on a unit length of wire c if it is moved to position x.



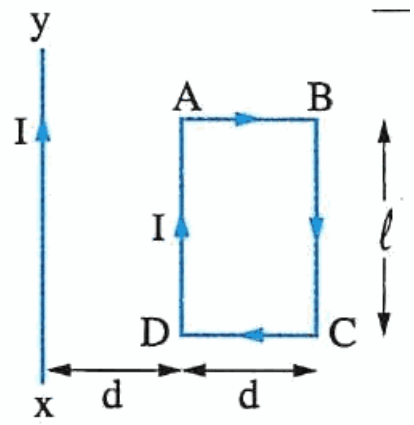
10 Three straight parallel wires a, b and c each carry an electric current as in the opposite figure. What happens to the magnitude and direction of the magnetic force acting on a unit length of wire a when each of the following changes is made:

(1) the current in wire b is reversed?

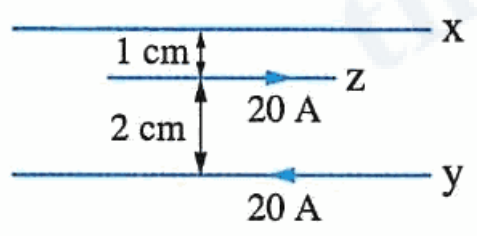
(2) the current in wire c is increased to three times its value?



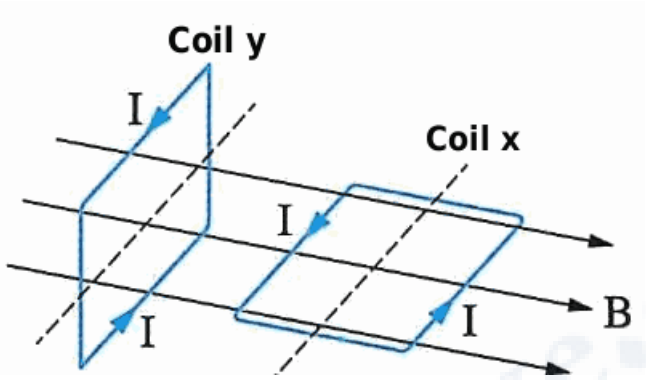
11 In the opposite figure, a rectangular metal frame (ABCD) of length ℓ and width d carries an electric current I, and in its plane there is a long wire xy carrying an electric current I at a distance d from the frame. Prove that the total magnetic force acting on the frame is given by the relation: $F = (\mu I^2 \ell)/(4 \pi d)$



12 Two long horizontal wires x and y lie in one vertical plane and carry electric currents I and 20 A respectively. A wire z, free to move, of length 1 m and weight 0.01 N, carrying a current of 20 A, is placed in their plane as in the opposite figure. Find the value and direction of the current in wire x that keeps wire z in equilibrium.



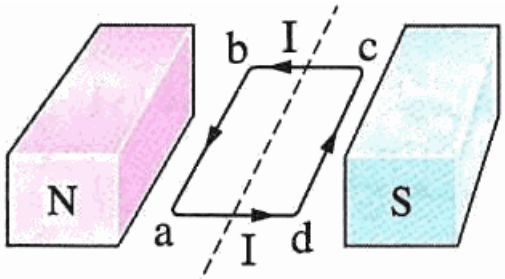
13 Two identical coils x and y are placed in a uniform magnetic field (B) as in the opposite figure. When a direct current of the same value (I) is passed through each of them, coil x was observed to rotate and coil y did not rotate. Explain this.



14 A rectangular coil abcd, which can rotate about an axis parallel to its length ab, carries a direct current and is placed parallel to a uniform magnetic field as in the opposite figure:

(1) Determine the direction of rotation of the coil relative to the clockwise direction.

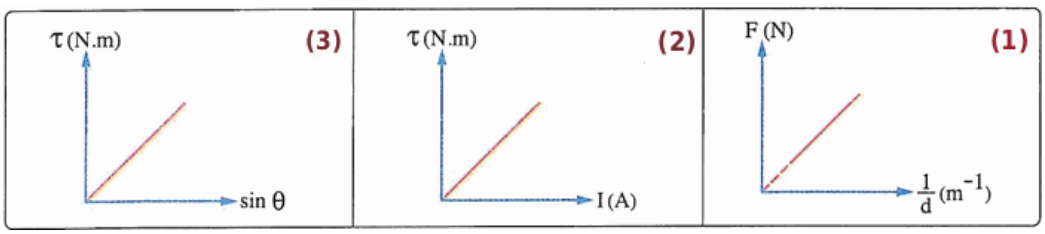
(2) Which sides of the coil are acted on by a magnetic force after it rotates a quarter of a turn?



15 A loop is placed in a uniform magnetic flux of density B, so the maximum magnetic flux that can pass through it is 1 Wb. Calculate the maximum torque that this field can exert on the loop when an electric current of 1 A passes through the loop.

16 Write the mathematical relation that each graph represents, and what the slope of the straight line equals, for each of the following:

where: (F) is the mutual magnetic force between two parallel wires, (I) is the current, (d) is the distance between the two wires, (τ) is the magnetic torque acting on a coil, (θ) is the angle between the normal to the plane of the coil and the flux lines.

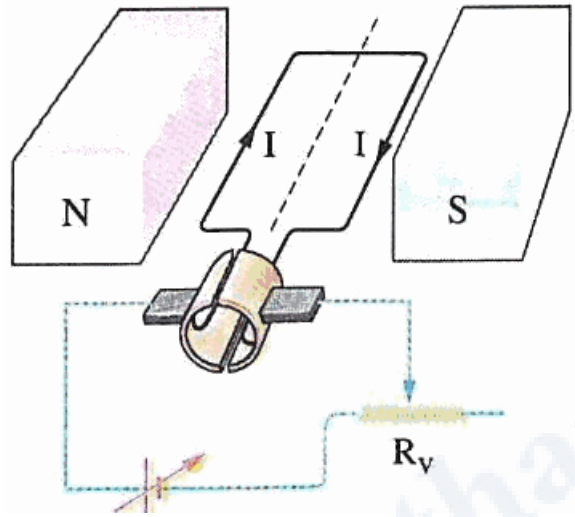


17 A circular coil of N turns, each of area $0.01\ m^2$ and resistance $1\ \Omega$ per turn, is connected to a source of negligible internal resistance and emf 2 V, and the coil is placed parallel to a magnetic field of flux density 1 T. Find the magnetic torque acting on it.

18 A straight wire of length ℓ is wound into a circular coil of radius r and N turns. The coil is placed parallel to the direction of a magnetic field of flux density B and an electric current I is passed through it. Prove that the maximum magnetic torque acting on it is given by the relation: $\tau = 1/2\ B\ I\ r\ \ell$

19 Two identical straight wires are each shaped into a circular coil. The number of turns of the first coil is three times that of the second coil. Find the ratio between the magnetic dipole moments of the two coils if an electric current I passes through each of them.

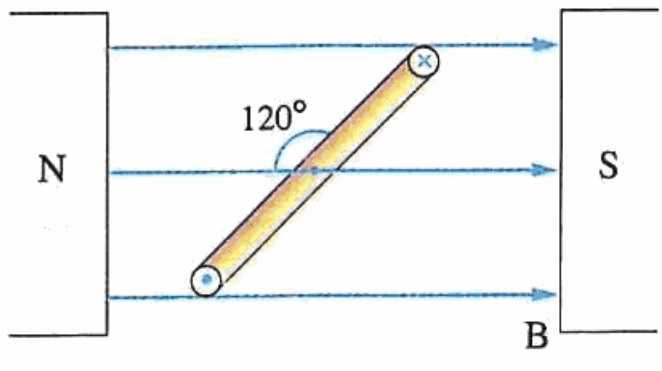
20 A rectangular coil is placed between the poles of a magnet and its ends are connected to a closed electric circuit as in the opposite figure. How can you increase both the magnetic dipole moment of the coil and the maximum magnetic torque acting on it without changing the specifications of the coil?



21 The opposite figure shows a front view of a rectangular coil whose dipole moment is $10\ A.m^2$, placed in a uniform magnetic field of flux density 0.1 T. Calculate:

(1) the torque acting on the coil in the position shown in the figure.

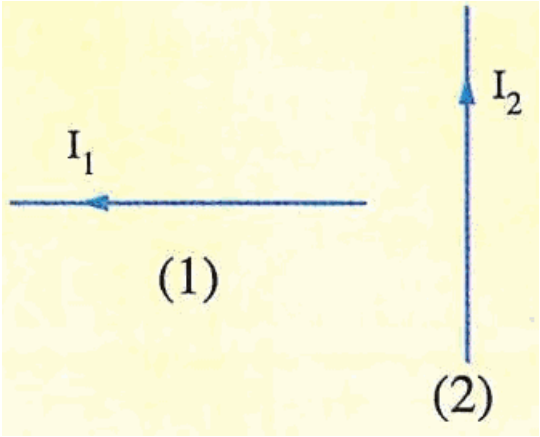
(2) the torque after the coil rotates clockwise through 60° from the position shown in the figure.



22 A straight wire of length (ℓ) is wound into a square coil of (N) turns. If an electric current (I) passes through it, prove that the magnetic dipole moment of the coil is given by the relation: $|m_d| = (I\,\ell^2)/(16\,N)$

Past exam questions — 52 questions

1 In front of you are two perpendicular wires (1) and (2) in one plane, carrying electric currents I_1 and I_2 respectively. The direction of the magnetic force acting at the midpoint of wire (1) due to the magnetic field produced by the current in wire (2) is ..... (Trial exam / May 2021)



(A) towards the top of the page

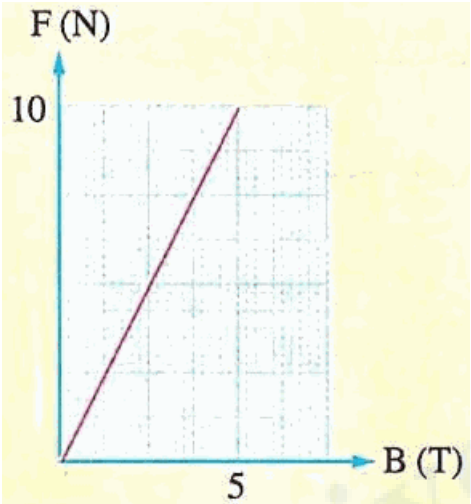
(B) towards the bottom of the page

(C) perpendicular to the plane of the page, inward

(D) perpendicular to the plane of the page, outward

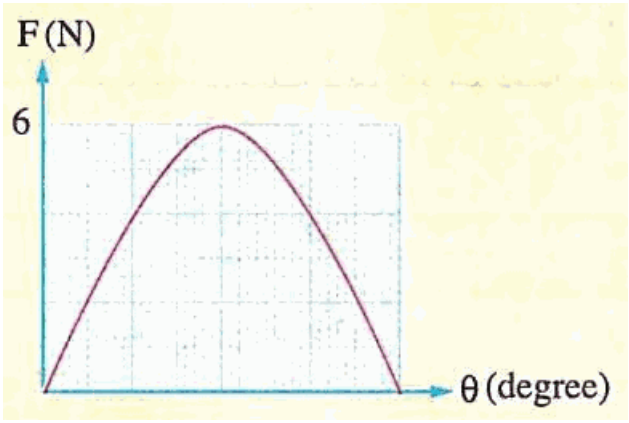
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2 A straight wire carrying an electric current is placed perpendicular to the direction of different magnetic fields. The opposite graph shows the relation between the magnetic force (F) acting on the wire and the magnetic flux density (B) in which the wire is placed. When the magnetic flux density is 3 T, the force acting on the wire is ..... newton. (Trial exam / June 2021)



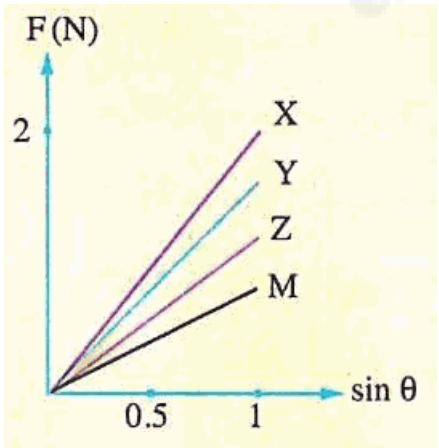
(A) 6 (B) 4 (C) *1/2* (D) 2

3 The opposite graph represents the relation between the magnetic force (F) acting on a wire carrying an electric current placed in a magnetic field of flux density (B) and the angle between the direction of the magnetic field and the wire (θ). When the angle (θ) equals ....., the magnetic force (F) acting on the wire equals half its maximum value. (1st session 2021)



(A) 30° (B) 45° (C) 60° (D) 120°

4 Four straight wires X, Y, Z and M of different lengths each carry an electric current I and are placed in a magnetic field of flux density B. The opposite graph shows the relation between the magnetic force (F) acting on each wire and the sine of the angle between each wire and the direction of the flux lines (sin θ). The longest wire is wire ..... (2nd session 2021)



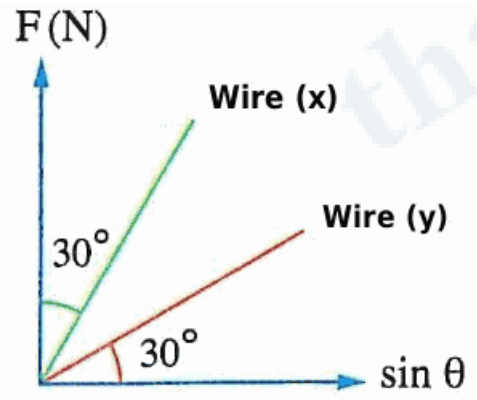
(A) X (B) Y (C) Z (D) M

5 Two wires x and y of equal length each carry an electric current and are placed perpendicular to a magnetic field directed out of the page with flux density B, as in the figure. The relation between the magnetic force F_x acting on wire x and the magnetic force F_y acting on wire y is ..... (1st session 2022)



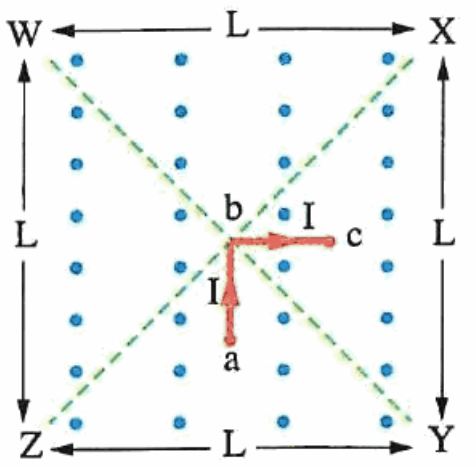
(A) $F_y > F_x$ and both are downward
(B) $F_y > F_x$ and both are upward
(C) $F_x > F_y$ and both are upward
(D) $F_x > F_y$ and both are downward

6 The graph shows the relation between the magnetic force (F) acting on two straight wires x and y and the sine of the angle (sin θ) between each wire and the direction of the magnetic field of flux density (B) in which they are placed. If the ratio of the current in wire (x) to the current in wire (y) $= 3/4$, the ratio of the length of wire (x) to the length of wire (y) equals ..... (2nd session 2022)



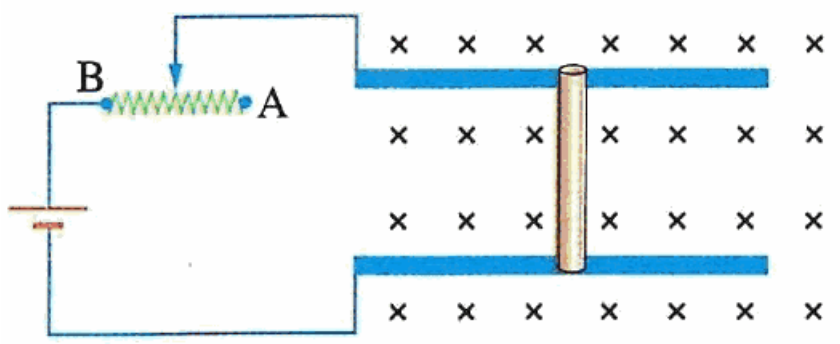
(A) *4/3*
(B) *4/9*
(C) *4/1*
(D) *8/3*

7 A straight metal wire carrying an electric current (I) is bent into two equal perpendicular parts ab and bc, then placed in a uniform magnetic field perpendicular to both parts of the wire as shown in the figure. Towards which point (W, X, Y, Z) does point b move? (2nd session 2022)



(A) Point Y (B) Point X (C) Point W (D) Point Z

8 A cylindrical metal rod rests on two copper strips fixed in the plane of the paper and connected to a cell and a rheostat. A uniform magnetic field perpendicular to the plane of the paper acts on the rod and the strips as in the figure, so a magnetic force (F) acts on the rod. Which of the following choices represents what happens to the magnitude and direction of the force F when the slider of the rheostat is moved towards point B? (Trial exam 2023)



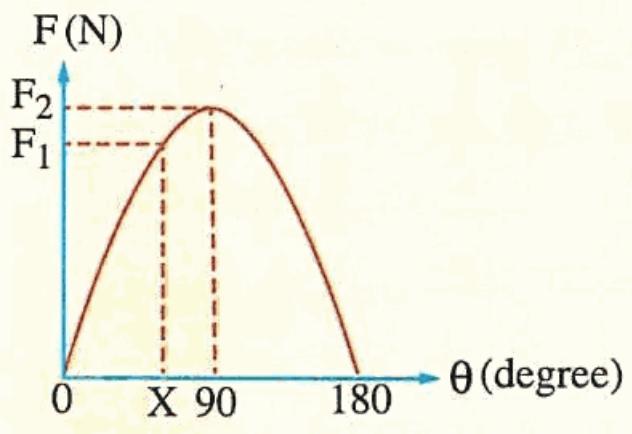
(A) Its magnitude decreases and it stays in the same direction

(B) Its magnitude increases and it stays in the same direction

(C) Its magnitude decreases and its direction is reversed

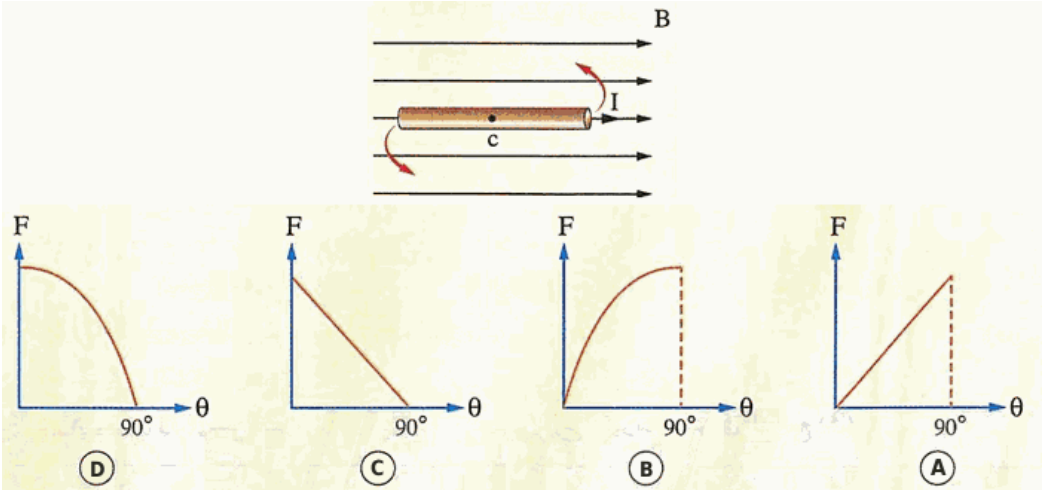
(D) Its magnitude increases and its direction is reversed

9 The opposite graph represents the relation between the magnetic force (F) acting on a straight wire of length ℓ carrying an electric current I placed in a uniform magnetic field of flux density B and the angle (θ) between the wire and the direction of the field. If the ratio (F_2/F_1) equals $(2\sqrt{3})/3$, the value of the angle X on the horizontal axis equals ..... (2nd session 2023)

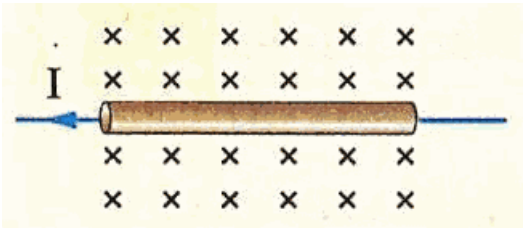


(A) 45° (B) 75° (C) 60° (D) 80°

10 In the opposite figure, a straight wire carrying an electric current (I) is placed parallel to a uniform magnetic field of flux density (B). If the wire rotates a quarter of a turn about an axis perpendicular to the plane of the page at point c, the graph that represents the relation between the magnetic force (F) acting on the wire and the angle of rotation (θ) is ..... (Sample exam 2025)



11 A wire of weight F is hung horizontally, and a uniform magnetic field of flux density B acts perpendicular to it as in the figure. When an electric current I passes through the wire, it is acted on by a magnetic force of 2 F. The magnitude of the resultant of the wire's weight and the magnetic force acting on it equals ..... (Sample exam 2025)



(A) F (B) 2 F (C) $\sqrt{(5)}\ F$ (D) 3 F

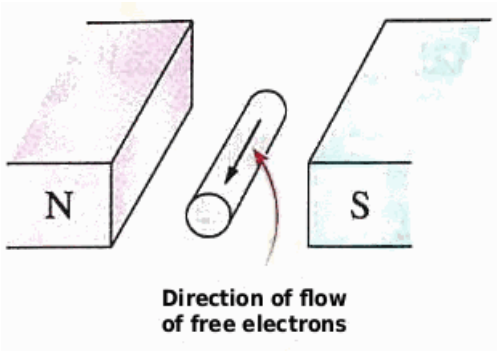
12 A solenoid has 250 turns/m and carries a current of 5 A. If a wire of length 0.35 m carrying a current of 10 A is placed along the axis of the solenoid, the magnetic force acting on the wire equals ..... (Sample exam 2025)

(A) zero (B) $5.5 \times 10^{-3}\ N$ (C) $7.5 \times 10^{-3}\ N$ (D) 0.01 N

13 An electron moves perpendicular to the plane of the page, outward, in a uniform magnetic field directed south in the plane of the page. The direction of the magnetic force acting on the moving electron is ..... (Sample exam 2025)

(A) east, in the plane of the page
(B) west, in the plane of the page
(C) north, in the plane of the page
(D) perpendicular to the plane of the page, inward

14 In the figure, a horizontal straight wire is placed perpendicular to the direction of the magnetic field of a magnet. When a current of free electrons passes through the wire, the wire is acted on by a magnetic force because of ..... (1st session 2025)



(A) a difference between the magnetic flux densities above and below the wire

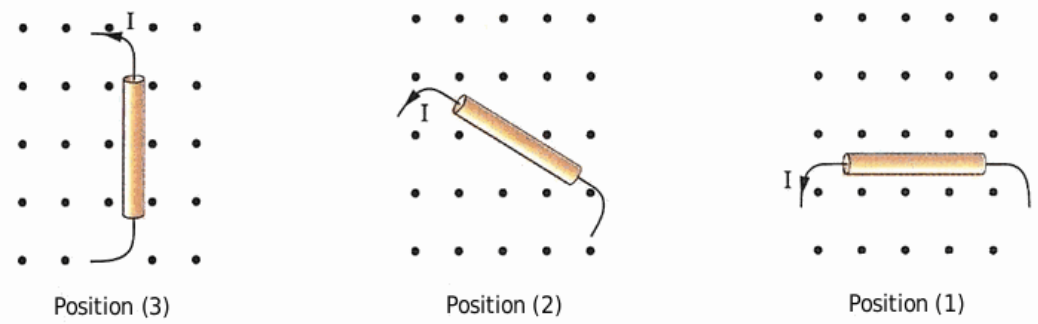
(B) the attraction of the free electrons inside it to the north pole of the magnet

(C) the attraction of the free electrons inside it to the south pole of the magnet

(D) a difference between the magnetic flux densities to the right and left of the wire

---

15 The following figures show a straight wire carrying an electric current (I) placed in different positions in the plane of the page in a uniform magnetic field perpendicular to the plane of the page. The magnetic force acting on the wire is ..... (2nd session 2025)



(A) equal in the three positions

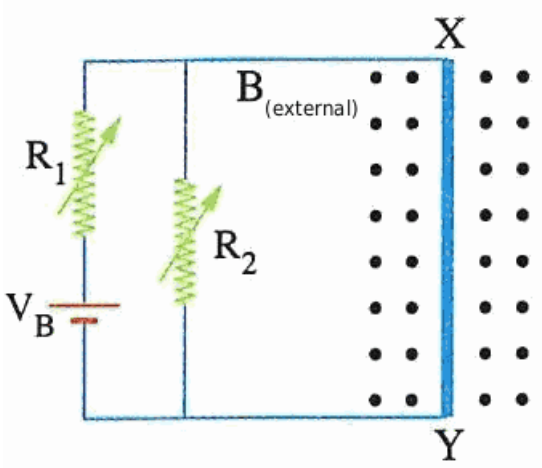
(B) greatest in position (1)

(C) greatest in position (2)

(D) greatest in position (3)

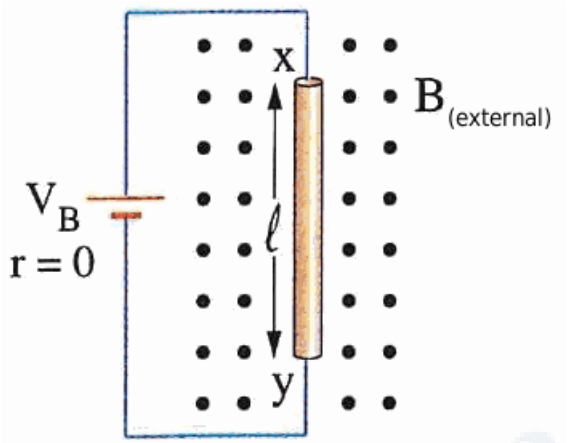
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16 In the electric circuit shown in the figure, a metal wire (XY) of resistance (R) is placed perpendicular to a uniform external magnetic field of flux density (B) and connected to a closed circuit containing a battery of emf (V_B) and negligible internal resistance and two rheostats (R_1) and (R_2). Which of the following actions, each done alone, on the values of the two rheostats (R_1) and (R_2) respectively causes a decrease in the magnetic force acting on wire (XY)? (Sample exam 2026)



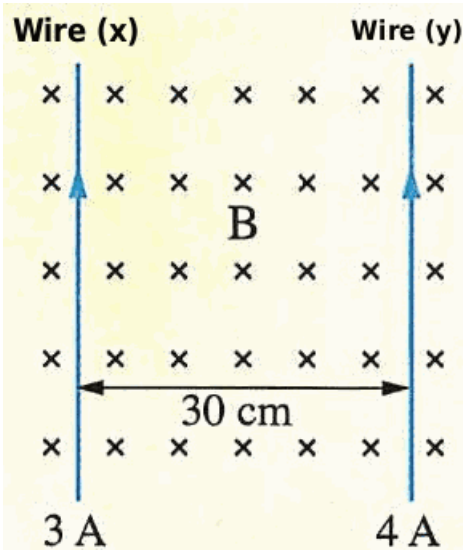
(A) increase, increase
(B) increase, decrease
(C) decrease, increase
(D) decrease, decrease

17 The figure shows a wire xy of uniform cross-section, length (ℓ) and resistance (R), connected to a battery of emf (V_B) and negligible internal resistance, and placed in a uniform magnetic field of flux density (B) perpendicular to the plane of the page, outward, so the magnetic force acting on it is (F). If the wire is stretched uniformly so that its length becomes (2ℓ), placed completely in the same field and connected to the same battery, the magnetic force acting on it ..... (Sample exam 2026)



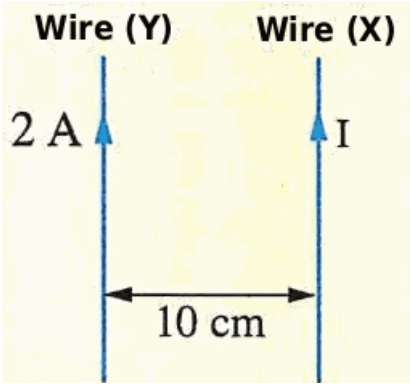
(A) decreases to half
(B) decreases to a quarter
(C) doubles
(D) does not change

18 Two wires (x) and (y), 30 cm apart, carry electric currents of 3 A and 4 A respectively, and both are in an external magnetic field of flux density B perpendicular to the plane of the page, inward, as in the figure. If the resultant magnetic force acting on a unit length of wire (x) equals $2 \times 10^{-5}\ N/m$, the value of B equals ..... (Trial exam / June 2021)



(A) $6.67 \times 10^{-6}\ T$ (B) $9.3 \times 10^{-6}\ T$ (C) $4 \times 10^{-6}\ T$ (D) $2.67 \times 10^{-6}\ T$

19 The figure shows two parallel wires (Y) and (X). If the magnetic force acting on a unit length of either wire is $4 \times 10^{-5}\ N/m$, the electric current (I) in wire (X) equals ..... (1st session 2021)



(A) 0.1 A (B) 1 A (C) 10 A (D) 100 A

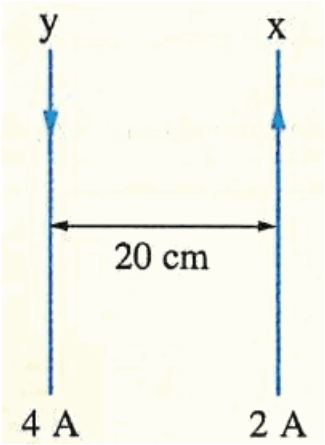
20 Two parallel wires (z) and (y) carry electric currents of 5 A and 6 A respectively and are 0.4 m apart. Both are in an external magnetic field of flux density 2.5×10^{-5} tesla directed perpendicular to the page, inward, as in the figure. The resultant magnetic force acting on a unit length of wire (z) is approximately ..... (2nd session 2021)



(A) $1.5 \times 10^{-5}\ N/m$ (B) $1.5 \times 10^{-4}\ N/m$ (C) $1.7 \times 10^{-4}\ N/m$ (D) $4 \times 10^{-5}\ N/m$

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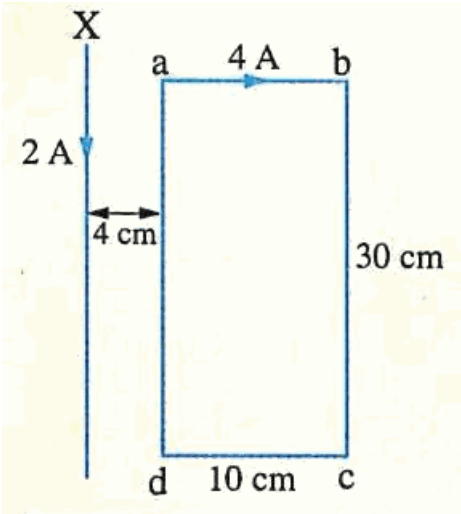
21 The figure shows two wires x and y, each 1.6 m long and 20 cm apart, carrying electric currents of 2 A and 4 A respectively. The mutual magnetic force between the two wires is ..... (1st session 2022)



(A) $1.28 \times 10^{-4}\ N$ (B) $1.28 \times 10^{-6}\ N$ (C) $1.28 \times 10^{-7}\ N$ (D) $1.28 \times 10^{-5}\ N$

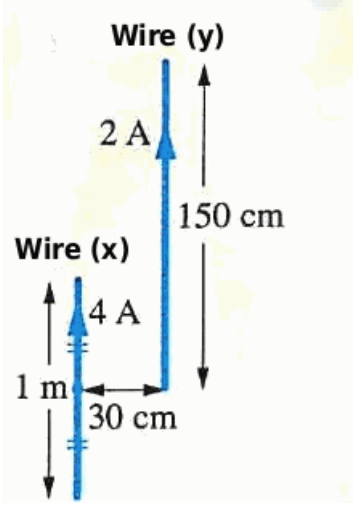
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22 In the opposite figure, a wire in the shape of a rectangle (abcd) carries a current of 4 A, and in its plane, 4 cm from it, is a wire X carrying a current of 2 A. The magnitude and direction of the resultant magnetic force acting on wire X are ..... (1st session 2022)



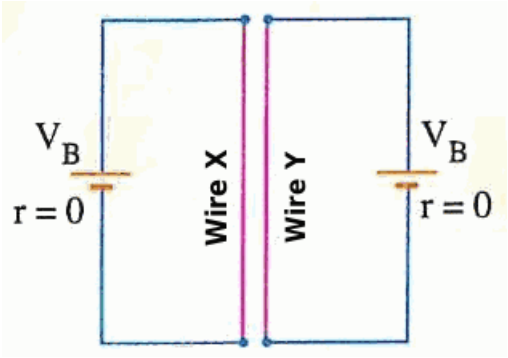
(A) 1.54×10^{-5} N, to the left
(B) 1.54×10^{-5} N, to the right
(C) 8.57×10^{-6} N, to the right
(D) 8.57×10^{-6} N, to the left

23 Two straight parallel wires x and y carry electric currents as in the figure. The mutual magnetic force between the two wires equals ..... (2nd session 2022)



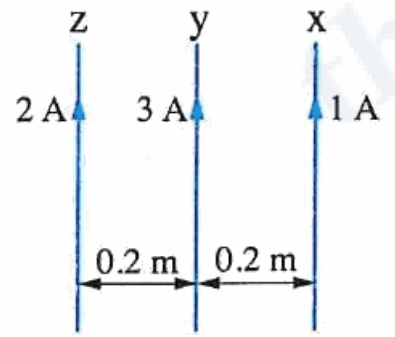
(A) 2.67×10^{-6} N
(B) 8×10^{-6} N
(C) 5×10^{-6} N
(D) 5.33×10^{-6} N

24 In the figure, two long parallel wires X and Y are each connected to a source of emf of negligible internal resistance, and the mutual force between the two wires is (F). When wire X is replaced by another wire of the same length and radius whose material has a resistivity *1/4* that of the material of wire X, the mutual force between the two wires becomes ..... (Trial exam 2023)



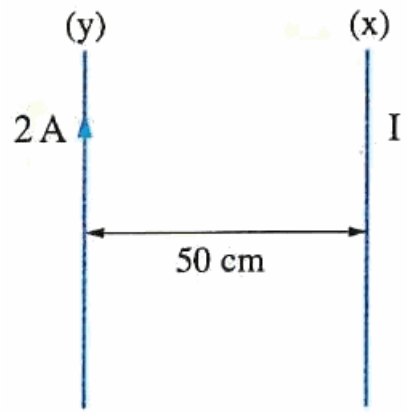
(A) 2 F (B) F (C) 4 F (D) *F/4*

25 From the data shown in the figure, which of the following choices represents the correct order of the magnetic forces acting on a unit length of each wire? (Trial exam 2023)



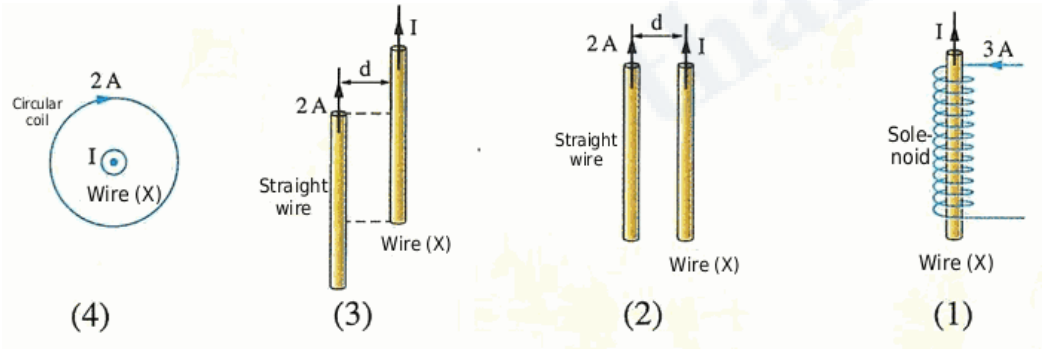
(A) $F_y < F_x < F_z$ (B) $F_z < F_y < F_x$ (C) $F_x < F_y < F_z$ (D) $F_y < F_z < F_x$

26 In the opposite figure, a unit length of wire (x) is acted on by a force of $2 \times 10^{-6}\ N/m$ to the right due to the magnetic flux produced by the current in wire (y). The value and direction of the current (I) are ..... (1st session 2023)



(A) 2.5 A, upward (B) 2.5 A, downward (C) 25 A, downward (D) 25 A, upward

27 A wire (X) carrying a current (I) is placed in magnetic fields produced by different sources as in the following figures. Which of the following represents the correct order of the magnetic force acting on wire (X) in each figure? (1st session 2023)

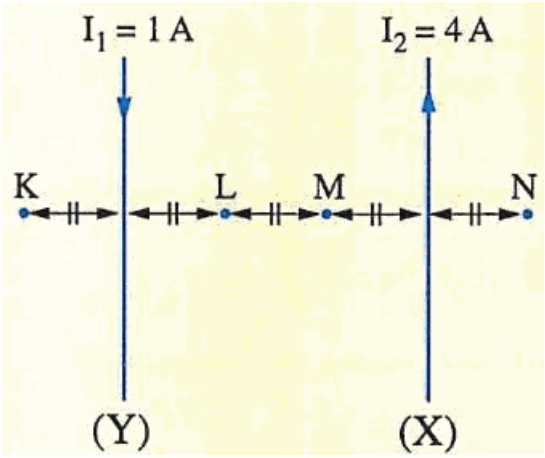


(A) $F_2 > F_3 > F_1 = F_4$ (B) $F_2 = F_3 > F_1 = F_4$
(C) $F_1 > F_2 > F_3 > F_4$ (D) $F_1 > F_2 = F_3 = F_4$

28 Two straight parallel wires (A, B) carry electric currents in opposite directions of 2 A and I respectively. If the perpendicular distance between the two wires is 5 cm, the length of their facing part is 10 cm, and the mutual magnetic force between them is $2.4 \times 10^{-6}\ N$, the current (I) and the type of the mutual force between the two wires are ..... (2nd session 2023)

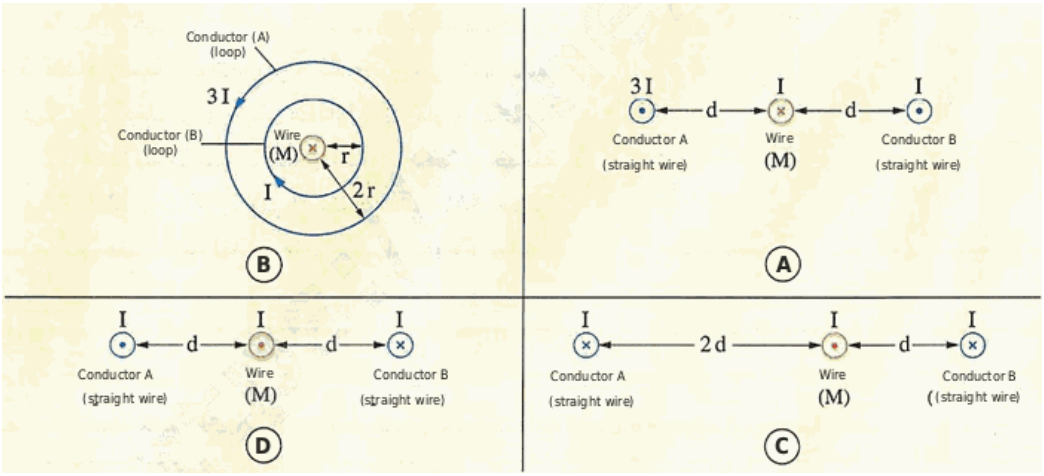
(A) 3 A, repulsion (B) 3 A, attraction (C) 6 A, repulsion (D) 6 A, attraction

29 In the opposite figure, at which of the points K, L, M, N should a straight wire carrying an electric current be placed, parallel to the two wires X and Y and in their plane, so that it is not acted on by a magnetic force? (1st session 2024)

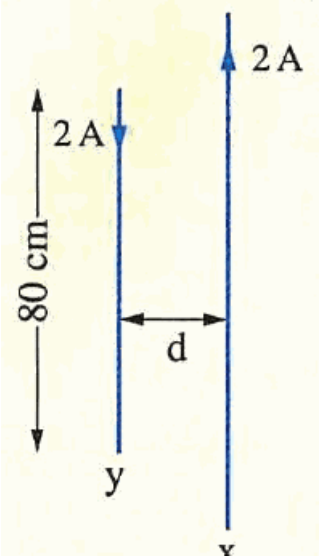


(A) K (B) L (C) M (D) N

30 In each of the following figures, a straight wire (M) carrying an electric current is placed perpendicular to the plane of the page and is surrounded by two different conductors (A, B), each carrying an electric current. In which of these figures is wire (M) NOT acted on by a magnetic force due to the magnetic field produced by the two conductors (A, B)? (1st session 2024)

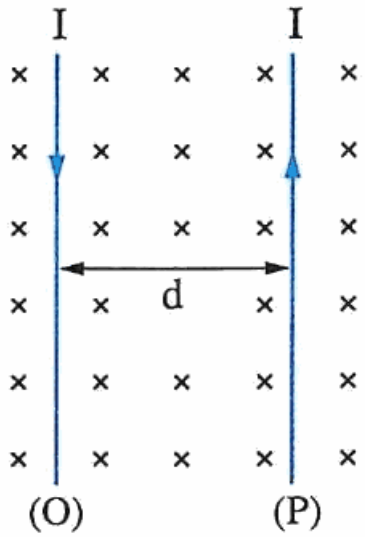


31 Two straight parallel wires (x) and (y): wire (x) is very long and wire (y) is 80 cm long, and each carries an electric current as in the opposite figure. If the mutual force between the two wires is 2×10^{-5} N, the perpendicular distance between the two wires (d) equals ..... (2nd session 2024)



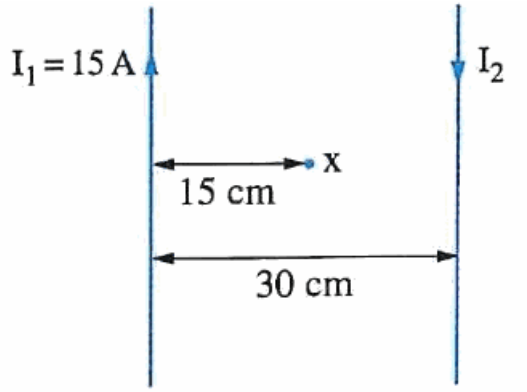
(A) 3.2 cm (B) 0.32 cm (C) 0.032 cm (D) 0.0032 cm

32 Two long parallel wires (P) and (O) in the plane of the page, a distance (d) apart, carry electric currents in opposite directions of the same value (I), and are in a uniform magnetic field as in the figure, of flux density $((\mu I)/(\pi d))$. If wire (P) can move and wire (O) is fixed in its place, in which direction is the magnetic force acting on wire (P)? (2nd session 2024)



(A) It is not acted on by a magnetic force (B) Towards the left of the page
(C) Towards the right of the page (D) Perpendicular to the plane of the page

33 In the opposite figure, two long straight parallel wires are 30 cm apart, and the first wire carries an electric current of 15 A. If the resultant magnetic flux density at point (x), midway between the two wires, equals 6×10^{-5} T, the mutual magnetic force per unit length between the two wires, acting on either of them, equals ..... (Sample exam 2025)



(A) 2×10^{-4} N (B) 3×10^{-4} N (C) 4×10^{-4} N (D) 5×10^{-4} N

34 Figure (1) shows two straight parallel wires (X) and (Y) carrying electric currents (2 I) and (I) respectively, and the mutual magnetic force between the two wires is F. When both wires are placed in an external magnetic field of flux density (B) as shown in figure (2), the resultant magnetic force acting on wire (X) becomes zero. The resultant magnetic force acting on wire (Y) is then ..... (Sample exam 2025)

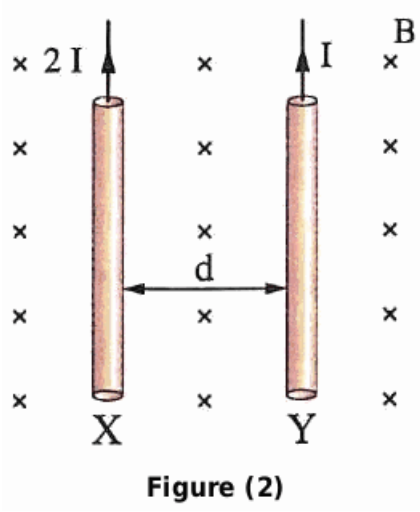


Figure (2)

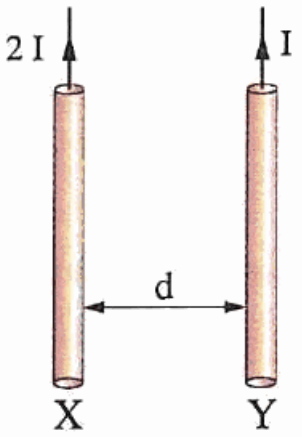


Figure (1)

(A) 0.5 F (B) 1 F (C) 1.5 F (D) 2 F

35 A square coil MNOP, free to move, consists of one turn and carries an electric current I_1. Near it, in the same plane, is a long fixed straight wire AB carrying a current I_2, as in the opposite figure. If the resultant magnetic force acting on the wire equals F, study the following statements:

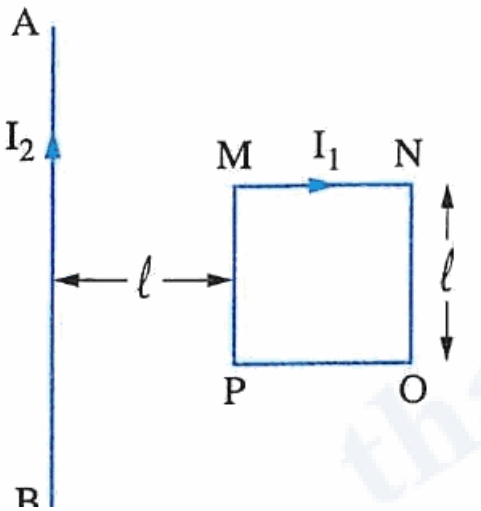
(I) The mutual magnetic force between wire AB and side MP equals 2 F

(II) The mutual magnetic force between wire AB and side NO equals F

(III) The coil rotates anticlockwise

(IV) The coil moves towards the straight wire

Which of the previous statements are correct? (Sample exam 2025)



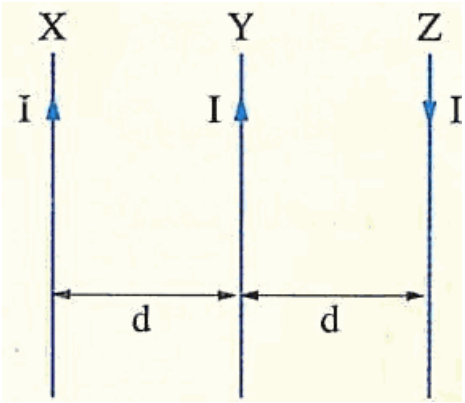
(A) (I), (II), (IV) only

(B) (I), (II) only

(C) (II), (IV) only

(D) (I), (II), (III), (IV)

36 Three identical straight wires each carry an electric current (I) and are placed parallel, with the perpendicular distances between them as shown in the figure. Which wire is acted on by the smallest magnetic force? (1st session 2025)



(A) The three wires are acted on by the same force

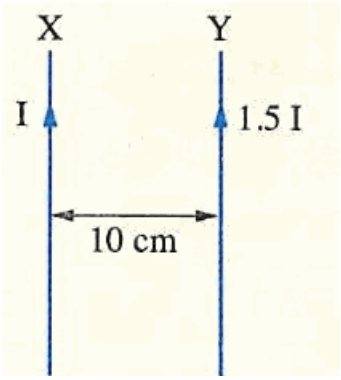
(B) Wire (Y)

(C) Wire (Z)

(D) Wire (X)

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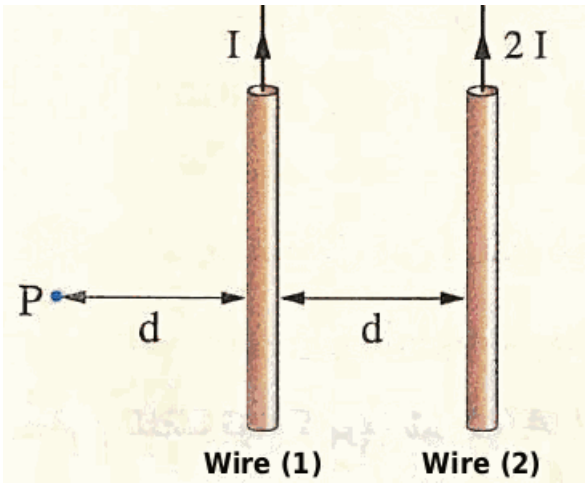
37 Two straight parallel wires X and Y, 10 cm apart, carry electric currents I and 1.5 I respectively, as in the opposite figure. If the mutual magnetic force between the two wires per unit length is $1.2 \times 10^{-5}\ N/m$, the current (I) equals ..... (2nd session 2025)



(A) 2 A (B) 1 A (C) 1.5 A (D) 2.5 A

---

38 Two long straight parallel wires (1) and (2) each carry an electric current as in the opposite figure. If the total magnetic flux density at point (P) equals B, the magnetic force acting on a unit length of wire (1) equals ..... (Sample exam 2026)



(A) BI (B) 2 BI (C) $BI/2$ (D) $BI/4$

39 A circular coil of area $10\ cm^2$ consisting of 30 turns carries an electric current of 2 A and is placed in a magnetic field of flux density 0.3 T. If the direction of the magnetic dipole moment makes an angle of 30° with the direction of the magnetic field, the magnetic torque acting on the coil is ..... (Trial exam / May 2021)

(A) $9\sqrt{(3)} \times 10^{-3}\ N.m$ (B) $18 \times 10^{-3}\ N.m$

(C) $18\sqrt{(3)} \times 10^{-3}\ N.m$ (D) $9 \times 10^{-3}\ N.m$

40 A rectangular coil carrying an electric current is placed parallel to the direction of a magnetic field of flux density 2 T. If the magnetic dipole moment of the coil is $0.3\ A.m^2$, the magnetic torque acting on the coil equals ..... (Trial exam / June 2021)

(A) 0.6 N.m (B) 0.15 N.m (C) 0.06 N.m (D) 0.015 N.m

41 A rectangular coil of 2 turns, 10 cm long and 2 cm wide, carries an electric current of 2 A and is placed in a magnetic field of flux density 2 T. The magnetic torque acting on the coil when the angle between the coil and the direction of the flux lines is 60° equals ..... (1st session 2021)

(A) $16 \times 10^{-3}\ N.m$ (B) $8\sqrt{(3)} \times 10^{-3}\ N.m$

(C) $8 \times 10^{-3}\ N.m$ (D) $16 \times 10^{-4}\ N.m$

42 If the torque acting on a coil carrying an electric current placed in a magnetic field equals 0.86 N.m when the angle between the normal to the plane of the coil and the direction of the magnetic flux is 60°, then when the plane of the coil is parallel to the magnetic flux lines, the torque becomes approximately ..... (2nd session 2021)

(A) 1 N.m (B) 1.5 N.m (C) 1.86 N.m (D) zero

43 A coil carrying an electric current is placed in a magnetic field of flux density 400 mT so that the angle between the plane of the coil and the direction of the magnetic flux is (θ). If the magnetic dipole moment divided by the magnetic torque $= 5\ T^{-1}$, the angle (θ) equals ..... (1st session 2022)

(A) 30° (B) 35° (C) 60° (D) 55°

44 A rectangular coil of dimensions 20 cm and 40 cm with 5 turns is placed in a magnetic field of flux density 0.02 T so that the plane of the coil makes an angle of 55° with the direction of the magnetic flux. When a current of 4 A passes through the coil, the magnetic torque acting on the coil equals ..... (2nd session 2022)

(A) $18.4 \times 10^{-3}\ N.m$ (B) $26.2 \times 10^{-3}\ N.m$

(C) $320 \times 10^{-3}\ N.m$ (D) $640 \times 10^{-3}\ N.m$

45 A rectangular coil of insulated wire, 0.1 m long and 0.05 m wide, with 50 turns, can rotate about an axis in its plane parallel to its length. It is placed perpendicular to a magnetic field so that a flux of $10^{-3}\ Wb$ passes through its face. If an electric current of 2 A passes through the coil, the torque equals ..... (Trial exam 2023)

(A) 0.1 N.m (B) zero (C) $5 \times 10^{-4}\ N.m$ (D) $2 \times 10^{-3}\ N.m$

46 A rectangular coil carrying an electric current (I) is placed in a magnetic field of flux density (B) so that the plane of the coil makes an angle of 60° with the direction of the magnetic flux. If the value of the dipole moment in $(A.m^2)$ equals 4 times the value of the magnetic torque acting on the coil in (N.m), the magnetic flux density (B) equals ..... (1st session 2023)

(A) 3.46 T (B) 2 T (C) 8 T (D) 0.5 T

47 A rectangular coil carrying an electric current is placed in a magnetic field with its plane inclined at 60° to the magnetic field lines. The value of the magnetic torque acting on the coil in (N.m) equals the value of the magnetic dipole moment of the coil in $(A.m^2)$. The magnetic flux density equals ..... (2nd session 2023)

(A) 2 T (B) 1.15 T (C) 0.5 T (D) 0.86 T

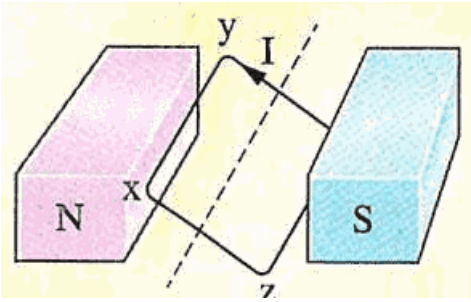
48 A rectangular coil carrying an electric current is inclined at 30° to the lines of a uniform magnetic field of flux density 0.5 T. If the magnetic dipole moment of the coil is $120\ A.m^2$, the magnetic torque acting on the coil is approximately ..... (Sample exam 2025)

(A) 75 N.m (B) 60 N.m (C) 52 N.m (D) 34 N.m

49 A straight wire is shaped into a circular coil of one turn, carries an electric current and is placed parallel to a uniform magnetic field, so it is acted on by a magnetic torque (τ). If the wire is reshaped into a circular coil of 3 turns, placed parallel to the same magnetic field and carrying the same current, the magnetic torque acting on the coil becomes ..... (Sample exam 2025)

(A) $3\ \tau$ (B) $(\tau)/3$ (C) $9\ \tau$ (D) $(\tau)/9$

50 A rectangular coil carries a direct current. The coil is placed in a uniform magnetic field of flux density $0.5\ Wb/m^2$ so that its plane is inclined at 60° to the direction of the field, as shown in the figure, and the coil is acted on by a torque of 14 N.m. What are the magnitude and direction of the magnetic dipole moment of the coil? (1st session 2025)



(A) $56\ A.m^2$, perpendicular to the plane of the coil and out of it

(B) $56\ A.m^2$, perpendicular to the plane of the coil and into it

(C) $32.3\ A.m^2$, perpendicular to the plane of the coil and into it

(D) $32.3\ A.m^2$, perpendicular to the plane of the coil and out of it

51 A direct current flows in a rectangular coil, making its magnetic dipole moment $56\ A.m^2$. The coil is placed at a certain angle in a uniform magnetic field of flux density $0.5\ Wb/m^2$, and it is acted on by a torque of 14 N.m. What is the angle between the plane of the coil and the direction of the magnetic field in this position? (2nd session 2025)

(A) 90° (B) 30° (C) 60° (D) 45°

52 A straight wire of length (ℓ) is shaped into a circular loop. If an electric current (I) passes through the loop, the magnetic dipole moment $(|m_d|)$ of the loop is given by the relation ..... (Sample exam 2026)

(A) $|m_d| = (I\ \ell^2)/(4\ \pi^2)$ (B) $|m_d| = (I\ \ell)/(4\ \pi^2)$

(C) $|m_d| = (I\ \ell^2)/(4\ \pi)$ (D) $|m_d| = (I\ \ell)/(4\ \pi)$

Answer key and solutions

Multiple choice questions

1 D	2 D	3 C	4 A	5 C	6 A	7 B	8 B	9 A	10 A
11 B	12 D	13 C	14 B	15 C	16 D	17 C	18 C	19 D	20 C
21 C	22 C	23 D	24 C	25 D	26 B	27 D	28 C	29 B	30 D
31 C	32 C	33 B	34 C	35 C	36 B	37 C	38 A	39 D	40 A
41 C	42 C	43 A	44 A	45 A	46 A	47 D	48 C	49 B	50 A
51 A	52 B	53 D	54 D	55 A	56 B	57 D	58 B	59 C	60 C
61 B	62 D	63 B	64 D	65 A	66 C	67 D	68 D	69 B	70 B
71 C	72 C	73 D	74 B	75 B	76 D	77 B	78 C	79 B	80 B
81 A	82 D	83 B	84 D	85 A	86 C	87 B	88 D	89 B	90 D
91 C	92 D	93 A	94 B	95 D	96 D	97 D	98 A	99 D	100 D
101 D	102 D	103 C	104 C	105 A	106 A	107 C	108 C	109 C	110 A
111 C	112 D	113 C	114 A	115 A	116 B				

1 **Answer (D)**

We use the right-hand rule for the force: fingers along the field, thumb along the current, and the force is perpendicular to the palm.

In (D): the field is from N to S (downward) and the current is into the page, so the force is to the left as shown in the figure.

In the other figures the force is opposite to the one shown.

2 **Answer (D)**

The current is out of the page and the field is into the page: the angle between them is 180°

$F = B\,I\,\ell\,\sin 180^\circ = 0$

3 **Answer (C)**

The field of the loop at its centre is perpendicular to the plane of the loop, so it lies along the wire.
The current in the wire is parallel to the field, so no force acts on it: $F = BI\ell\sin 0^\circ = 0$

4 **Answer (A)**

$F/(\ell) = B\,I\sin 90^\circ = 0.1 \times 10 = 1\ N/m$

5 **Answer (C)**

$F = B\,I\ell\sin\theta$ and at $\theta = 0^\circ$: $\sin 0^\circ = 0$

$F = 0$

6 **Answer (A)**

$F = B\,I\ell\sin 45^\circ = 1 \times 5 \times 0.1 \times 0.707 = 0.354\ N$

7 **Answer (B)**

$F = B\,I\ell\sin 90^\circ = 1 \times 5 \times 0.1 = 0.5\ N$

8 **Answer (B)**

$F = B\,I\ell\sin 135^\circ = 1 \times 5 \times 0.1 \times 0.707 = 0.354\ N$

9 **Answer (A)**

$F = B\,I\ell\sin 180^\circ = 0$

10 **Answer (A)**

$\sin\theta = F/(BI\ell) = 3/(5 \times 4 \times 0.3) = 0.5$

$\theta = 30^\circ$

11 **Answer (B)**

$F = BI\ell\sin 90^\circ$, so when I and ℓ are constant, F is directly proportional to B
A straight line passing through the origin.

12 **Answer (D)**

At first the wire is perpendicular to the field (F is maximum), then it rotates about an axis perpendicular to it.

The angle between the wire and the field $= 90° - \theta$, so $F = BI\ell\cos\theta$

It starts at its maximum value and decreases along a concave curve to zero at $\theta = 90°$

13 **Answer (C)**

Slope of the line $= B\ell = 1.2/2 = 0.6$

$B = 0.6/0.6 = 1\ T$

14 **Answer (B)**

$F = BI\ell\sin\theta$, so the slope of the $F-\ell$ line is $BI\sin\theta$

Group y is perpendicular: its slope is BI, and the slope of x is half the slope of y in the graph

$\sin\theta = 1/2 \Rightarrow \theta = 30°$

15 **Answer (C)**

$F = BI\ell\sin\theta$, so the slope of the line $= BI\ell$, which equals the tangent of the angle between the line and the horizontal axis

$I_x/I_y = \text{fractan } 30°\tan 60° = (1/\sqrt{(3)})/(\sqrt{(3)}) = 1/3$

16 **Answer (D)**

At $90°$, F has its maximum value $= 10\ N$, and the angle axis is divided into three equal parts: $30°$, $60°$, $90°$

F_0 is at $60°$: $F_0 = 10\sin 60° = 5\sqrt{(3)}\ N$

17 **Answer (C)**

The wire is perpendicular to the field: $F = BI\ell = 0.4 \times 5 \times 2 = 4\ N$

The current is upward and the field is to the left: by the right-hand rule the force is out of the page.

18 **Answer (C)**

At end Q the field is into the page and the current is to the left, so the force is downward

At end P the field is out of the page, so the force is upward (opposite to Q)

So the wire rotates: P upward and Q downward

19 **Answer (D)**

The wire is perpendicular to the field in all three positions $(\theta = 90^\circ)$ and has the same length and current

$F = BI\ell$ in all of them, so the forces are equal

20 **Answer (C)**

$F_1 = BI\ell$ (the wire is perpendicular to the field)

$F_2 = B/2 \times 2I \times 2\ell = 2BI\ell$ (perpendicular to the field)

$F_3 = 2B \times 3I \times \ell \times \sin 30^\circ = 3BI\ell$

$F_3 > F_2 > F_1$

21 **Answer (C)**

The force is proportional to $\sin\theta$, where θ is the angle between the wire and the field

(1) The field is perpendicular to the page: $\sin 90^\circ = 1$

(2) The field is vertical and the wire is inclined 60° to the horizontal, i.e. 30° to the vertical: $\sin 30^\circ = 0.5$

(3) The field is horizontal and the wire makes 60° with it: $\sin 60^\circ = 0.87$

Order: $(1) > (3) > (2)$

22 **Answer (C)**

The force depends on the component of the wire's length perpendicular to the field: the field is horizontal, so the vertical component matters.

Wires ab and bc have the same vertical displacement (from a to b, then from b to c back to the same horizontal level)

So the magnitude of the force on bc equals F (and its direction is opposite)

23 **Answer (D)**

Part ab is horizontal and parallel to the direction of the field: $\theta = 0$

$F = BI\ell \sin 0^\circ = 0$

24 **Answer (C)**

Part bc is vertical and perpendicular to the field, with length $16\ cm$

$F = BI\ell = 0.15 \times 5 \times 0.16 = 0.12\ N$

25 **Answer (D)**

Wire cd is inclined at 30° to the direction of the field (since it makes 60° with the vertical)

$F = BI\ell \sin 30^\circ = 0.15 \times 5 \times 0.32 \times 0.5 = 0.12\ N$

26 **Answer (B)**

$F_{ab} = BI\ell$ and $F_{bc} = BI(2\ell)$, as both are perpendicular to the field

$(F_{ab})/(F_{bc}) = (\ell)/(2\ell) = 1/2$, less than one

27 **Answer (D)**

The field is out of the page and the current is to the right, so by the right-hand rule the magnetic force is downward, i.e. in the same direction as the weight.

Resultant $= F + 2F = 3F$

28 **Answer (C)**

$I = V/R = 6/2 = 3\ A$

$F = BI\ell = 0.1 \times 3 \times 0.2 = 0.06\ N$

$a = F/m = 0.06/0.4 = 0.15\ m/s^2$

29 **Answer (B)**

$I = F/(B\ell) = 2.4/(0.2 \times 1.5) = 8\ A$

The field is out of the page and the force is downward: by the right-hand rule the force is downward when the current is from b to a (to the right)

30 **Answer (D)**

When the switch is open, the total resistance is $R + 2R = 3R$, so $I = V/3R$ and $F_0 = BI\ell$

When the switch is closed, the resistance $2R$ is short-circuited, so $I' = V/R = 3I$

$F' = 3F_0$

31 **Answer (C)**

$I = V/R = VA/(\rho\ell)$, so $F = BI\ell = BVA/(\rho)$

The force does not depend on the length, so it is the same for both wires.

32 **Answer (C)**

$F = BI\ell = B\,(V\,A)/(\rho\ \ell)\ \ell = BVA/(\rho)$

$F = (10^{-3} \times 3 \times 10 \times 10^{-6})/(2.8 \times 10^{-8}) = 1.07\ N$

33 **Answer (B)**

$F = BVA/(\rho) \propto A$, and doubling the diameter makes the area four times as large

$F' = 4 \times 1.07 = 4.28\ N$

34 **Answer (C)**

The wire's field at a point $10\ cm$ away: $B_w = (\mu_0 I)/(2\pi d) \Rightarrow I = (10^{-5} \times 2\pi \times 0.1)/(4\pi \times 10^{-7}) = 5\ A$

$F/(\ell) = BI\sin\theta = 1.5 \times 5 \times 0.5 = 3.75\ N/m$

35 **Answer (C)**

For the wire to stay suspended: $BI\ell = mg = \rho A\ell g$

$B = (\rho A g)/I = (2700 \times 0.1 \times 10^{-4} \times 10)/10 = 27 \times 10^{-3}\ T$

The current in XY is from X to Y (to the right) and the required force is upward, so by the right-hand rule the field is into the page

36 **Answer (B)**

Only the lower side is inside the field. The current (anticlockwise) is to the right in it and the field is out of the page, so the force is downward.

The force increases the reading from 2 to $2.2\ N$, i.e. $F = 0.2\ N$

$B = F/(I\ell) = 0.2/(20 \times 0.2) = 0.05\ T$

37 **Answer (C)**

When the field is reversed, the force is reversed and becomes upward with the same magnitude $0.2\ N$

Reading $= 2 - 0.2 = 1.8\ N$

38 **Answer (A)**

The resultant is $3w$ downward, i.e. $F_m - w = -3w$, so the magnetic force is $F_m = 2w$ downward

When the field is reversed it becomes $2w$ upward, so the resultant is $2w - w = w$ vertically upward

39 **Answer (D)**

$F_m = 2w$ downward, and when the current is halved it becomes $F_m = w$ downward

Resultant $= w + w = 2w$ vertically downward

40 **Answer (A)**

For the tension to be zero, the upward magnetic force must equal the weight: $BI\ell = mg$

$I = mg/(B\ell) = (0.05 \times 10)/(0.2 \times 0.4) = 6.25\ A$

The field is into the page and the force is upward: the current is from b to a

41 **Answer (C)**

When the current is reversed, the magnetic force becomes $0.5\ N$ downward, added to the weight $0.5\ N$

The total tension $1\ N$ is shared by the two springs: $1/2 = 0.5\ N$ each

42 **Answer (C)**

The two currents are in opposite directions, so the two wires repel.

Wire (B) is on the left, so the force on it is to the left.

43 **Answer (A)**

The current in each wire produces a field that acts on the other wire.

The type of the force (attraction or repulsion) is decided by the directions of the two currents: the same direction gives attraction, opposite directions give repulsion.

The values of the currents, the distance and the length decide only the magnitude of the force.

44 **Answer (A)**

The neutral point is where the total field of the two wires is zero, so their fields there are equal and opposite.

The neutral point lies between the two wires if the currents are in the same direction (attraction), and outside them if the currents are opposite (repulsion).

Point x is outside the two wires, so the wires repel

45 **Answer (A)**

In figure (1) the field lines surround both wires together and the field between them is weak: the currents are in the same direction, so the wires attract.

In figure (2) the two fields between the wires are in the same direction and strengthen each other: the currents are opposite, so the wires repel.

46 **Answer (A)**

The two mutual forces between the wires are action and reaction according to Newton's third law: equal in magnitude and opposite in direction.

$F_x/F_y = 1/1$

47 **Answer (D)**

The two mutual forces between the wires are action and reaction and are always equal; each is $F = (\mu\, I_x\, I_y)/(2\pi\, d)\, \ell$

Doubling the current in x doubles the force on both wires, so it becomes $2F_0$ on each

48 **Answer (C)**

$F/(\ell) = (\mu_0 I^2)/(2\pi) \times 1/d$, so the slope of the line $= (\mu_0 I^2)/(2\pi)$

Slope $= (4 \times 10^{-5})/40 = 10^{-6}$, so $2 \times 10^{-7} I^2 = 10^{-6}$

$I^2 = 5 \Rightarrow I = 2.24\ A$

49 **Answer (B)**

$F/(\ell) = (2 \times 10^{-7} I_1 I_2)/d \Rightarrow d = (2 \times 10^{-7} \times 10 \times 10)/(2 \times 10^{-4}) = 0.1\ m = 10\ cm$

50 **Answer (A)**

$F \propto (I_1 I_2)/d$

Doubling one current doubles the force, and halving the distance doubles it too: $F' = 2 \times 2 \times 0.01 = 0.04\ N$

51 **Answer (A)**

$F/(\ell) = (2 \times 10^{-7} I_a I_b)/d \Rightarrow I_b = (8.8 \times 10^{-4} \times 0.06)/(2 \times 10^{-7} \times 24) = 11\ A$

The force is attraction, so the two currents are in the same direction: out of the page.

52 **Answer (B)**

$F = (\mu I_1 I_2)/(2\pi d)\ \ell$, so when the other factors are constant, F is directly proportional to I_1

A straight line passing through the origin.

53 **Answer (D)**

$F \propto 1/d$ when the two currents and the length are constant

An inverse relation: a falling curve that does not touch the axes.

54 **Answer (D)**

The distance increases with time: $d = d_0 + vt$, so $F \propto 1/(d_0 + vt)$

A falling curve that starts from a definite value at $t = 0$ and never becomes zero

55 **Answer (A)**

$B = (\mu I)/(2\pi d) = (2 \times 10^{-7} \times 5)/0.1 = 10^{-5}\ T$

56 **Answer (B)**

$F = BI\ell = 10^{-5} \times 2 \times 0.5 = 10^{-5}\ N$

57 **Answer (D)**

The field is zero at the midpoint between the two wires (with currents in the same direction), so their fields are equal: $I_1 = I_2 = I$

$F/(\ell) = (2\times10^{-7}\ I^2)/d \Rightarrow 4\times10^{-5} = (2\times10^{-7}\ I^2)/2 \Rightarrow I^2 = 400$

$I = 20\ A$ in each of them

58 **Answer (B)**

$F \propto I\ I_x$, where the current in x becomes $I + 4$ and $F' = 2F$

$(I + 4)/I = 2 \Rightarrow I = 4\ A$

59 **Answer (C)**

Wire ab is acted on by a resultant force if the field of the other conductor acts on it with an unbalanced force (parallel wires, perpendicular wires without symmetry, or inside the field of a loop)

In (C) wire ab is parallel to the axis of the solenoid, and the field of the solenoid on the axis is parallel to ab, so it exerts no force: $F = BI\ell\sin 0^\circ = 0$

60 **Answer (C)**

The two currents branch from $8\ A$, so $I_A + I_B = 8$ and the force $F \propto I_A\ I_B$

The product is greatest when the two currents are equal: $4\times 4 = 16$

While in the others: $6\times 2 = 12$, $5\times 3 = 15$ and $2\times 6 = 12$

61 **Answer (B)**

The two currents are in the same direction, so the wires attract, and the external field pushes both wires to the left with the same force (current upward and field into the page).

The mutual force: on wire (1) it is to the left (towards (2)), and on wire (2) it is to the right (towards (1)).

On (1) the two forces add in the same direction, and on (2) they are opposite: $F_1 > F_2$

62 **Answer (D)**

The force from the external field: $BI = 2\times10^{-5}\times 2 = 4\times10^{-5}\ N/m$ downward on each wire (current to the right and field out of the page)

The mutual force (attraction): $(2\times10^{-7}\times 2\times 2)/0.01 = 8\times10^{-5}\ N/m$, on wire x downward (towards y)

On x the two forces are in the same direction: $4\times10^{-5} + 8\times10^{-5} = 1.2\times10^{-4}\ N/m$

63 **Answer (B)**

On wire y the force from the field is $4\times10^{-5}\ N/m$ downward, and the mutual force is $8\times10^{-5}\ N/m$ upward (towards x)

Resultant $= 8\times10^{-5} - 4\times10^{-5} = 4\times10^{-5}\ N/m$

64 **Answer (D)**

Parts of the frame attract each other if the currents in them are in the same direction, so they bend inward as in the figure.

When the source is connected between d and b, the current divides into two paths, and in each pair of opposite sides the current flows in the same direction, so they attract

65 **Answer (A)**

Weight per metre $= 0.12\times10^{-3}\times 10 = 1.2\times10^{-3}\ N/m$

$F/(\ell) = (2\times10^{-7}\ I_1\ I_2)/d = (2\times10^{-7}\times 80\times I_2)/0.2 = 8\times10^{-5}\ I_2$

To stay suspended: $8\times10^{-5}\ I_2 = 1.2\times10^{-3} \Rightarrow I_2 = 15\ A$

66 **Answer (C)**

Point P is at the midpoint, $0.1\ m$ from each wire, and the currents are opposite, so their fields are in the same direction

$B = (2\times10^{-7}\ (I_1 + I_2))/0.1 = 6\times10^{-5} \Rightarrow I_1 + I_2 = 30 \Rightarrow I_1 = 20\ A$

$F = (2\times10^{-7}\times 20\times 10)/0.2\times 0.5 = 10^{-4}\ N$

67 **Answer (D)**

At the neutral point x: $I_1/30 = I_2/10 \Rightarrow I_1 = 3I_2$

$F/(\ell) = (2\times10^{-7}\ I_1\ I_2)/0.2 = 12\times10^{-6} \Rightarrow I_1\ I_2 = 12$

$3I_2^2 = 12 \Rightarrow I_2 = 2\ A,\ I_1 = 6\ A$

68 **Answer (D)**

Wire ab is suspended: the magnetic force balances its weight $mg = 0.005\times 10 = 0.05\ N$

$(2\times10^{-7}\times 50\times 50)/d\times 1 = 0.05 \Rightarrow d = (5\times10^{-4})/0.05 = 0.01\ m$

69 **Answer (B)**

The upper side (near, $1\ cm$) and the lower side (far, $10\ cm$) are acted on by two opposite forces, and the upper one is larger because it is nearer

$F_{net} = 2\times10^{-7}\times 50\times I\times 0.25(1/0.01 - 1/0.1) = 2.25\times10^{-4}\ I$

To stay suspended: $2.25\times10^{-4}\ I = mg = 0.0045\times 10 = 0.045 \Rightarrow I = 200\ A$

The upper side must repel the wire (opposite currents), so the current is anticlockwise.

70 **Answer (B)**

The force on Y from X: $\propto (3I \times I)/d = (3I^2)/d$ towards X

The force on Y from Z: $\propto (3I \times 2I)/2d = (3I^2)/d$ towards Z

The two forces are equal and opposite, so their resultant on Y is zero

71 **Answer (C)**

We calculate the force on each wire in units of $(2 \times 10^{-7} I^2)/d$ (all are attractions because the currents are in the same direction)

On x: from y attraction 1 and from z attraction $2/2 = 1$ in the same direction: resultant 2

On y: from z attraction 2 and from x attraction 1 in the opposite direction: resultant 1

On z: from y attraction 2 and from x attraction $2/2 = 1$ in the same direction: resultant 3 (the greatest)

72 **Answer (C)**

The currents are in the same direction, so each wire attracts wire b

c (at distance d) attracts it to the right with a force $\propto 1/d$, and a (at distance $2d$) attracts it to the left with a force $\propto 1/2d$

So the resultant is to the right (towards c)

73 **Answer (D)**

From a (distance $0.2\ m$): $(2 \times 10^{-7} \times 5 \times 5)/0.2 = 25 \times 10^{-6}\ N/m$ attraction towards a

From c (distance $0.4\ m$): $(2 \times 10^{-7} \times 5 \times 5)/0.4 = 12.5 \times 10^{-6}\ N/m$ attraction towards c (opposite direction)

Resultant $= 25 \times 10^{-6} - 12.5 \times 10^{-6} = 12.5 \times 10^{-6}\ N/m$

74 **Answer (B)**

If the currents in a and c are opposite, one of them attracts b and the other repels it, so the two forces are in the same direction

Resultant $= 25 \times 10^{-6} + 12.5 \times 10^{-6} = 37.5 \times 10^{-6}\ N/m$

75 **Answer (B)**

At the neutral point (between the two wires) the two fields are equal: $I_1/x = I_2/(d - x)$

$2/x = 3/(10 - x) \Rightarrow 20 - 2x = 3x \Rightarrow x = 4\ cm$

76 **Answer (D)**

The previous neutral point is $4\ cm$ from the $2\ A$ wire and $6\ cm$ from the $3\ A$ wire

After reversing one current, their fields at this point are in the same direction: $B = 2\times10^{-7}(2/0.04 + 3/0.06) = 2\times10^{-5}\ T$

$F = BI\ell = 2\times10^{-5}\times 5\times 0.1 = 10^{-5}\ N$

77 **Answer (B)**

Assume the current in wire (3) is upward (from a to b) and calculate the force per metre

From wire (1) (current upward, distance $0.4\ m$): attraction to the right $= (2\times10^{-7}\times 12\ I_3)/0.4 = 6\times10^{-6}\ I_3$

From wire (2) (current downward, distance $0.1\ m$): repulsion to the left $= (2\times10^{-7}\times 5\ I_3)/0.1 = 10^{-5}\ I_3$

The resultant is to the left: $4\times10^{-6}\ I_3 = 3\times10^{-6} \Rightarrow I_3 = 0.75\ A$ from a to b

78 **Answer (C)**

The current in wire R is in the same direction as that in P, so it attracts it: the force is towards R (downward)

The current in wire Q is opposite to that in P, so it repels it: the force is away from Q (to the left)

The two distances are equal, so the resultant is in the direction halfway between downward and left: C

79 **Answer (B)**

On y: z (opposite current) repels it and pushes it towards x, and x (same direction) attracts it towards x too, so the two forces are in the same direction

$F\propto(2\ (I_2 + I_1))/d$

After reversing the current in x, the two forces are opposite: $F'\propto(2\ (I_1 - I_2))/d = F/2$

$I_1 - I_2 = (I_1 + I_2)/2 \Rightarrow I_1 = 3I_2 \Rightarrow I_1/I_2 = 3/1$

80 **Answer (B)**

We calculate the force on z in units of $u = (\mu\ I^2)/(2\pi\ d)$; all the wires attract because the currents are in the same direction

From y (I, distance d): 2 to the left, from x ($2I$, distance $2d$): 2 to the left, and from k (I, distance d): 2 to the right

Resultant $= 2 + 2 - 2 = 2$ units, i.e. $2\times(\mu\ I^2)/(2\pi\ d) = (\mu\ I^2)/(\pi\ d)$

81 **Answer (A)**

We calculate in units of $k = (\mu I^2)/(2\pi d)$ (all forces are attractions)

On z: y attracts it with force 1 upward and x with force $1/2$ upward, and m with force 1 downward: $F = 1/2$

On m: z with force 1, y with force $1/2$ and x with force $1/3$, all upward: $11/6$

$F_m/F_z = (11/6)/(1/2) = 11/3$

82 **Answer (D)**

We calculate in units of $(\mu I^2)/(2\pi d)$: the attraction of a wire at distance nd equals $1/n$

x and l (the two ends): all the wires attract them in one direction: $1 + 1/2 + 1/3 + 1/4 = 25/12$

y and k: $(1 + 1/2 + 1/3) - 1 = 5/6$

z (the middle): the two forces from the two sides are equal and balance: 0

$x = l > y = k > z$

83 **Answer (B)**

The torque $\tau = NBIA\sin\theta$, where θ is the angle between the field and the normal to the coil

It is maximum at $\theta = 90^\circ$, i.e. when the plane of the coil is parallel to the field

84 **Answer (D)**

Side ab is vertical and parallel to the axis of rotation, and the field is horizontal in all positions of the coil

So ab stays perpendicular to the field during rotation: $F = BI\ell$ is constant and does not change

85 **Answer (A)**

In the first position side bc is horizontal and parallel to the field, so there is no force on it: $F = 0$

During rotation its inclination to the field increases until it becomes perpendicular to it, so the force $F = BI\ell\sin\theta$ increases

86 **Answer (C)**

The torque $\tau = NBIA\cos\varphi$, where φ is the angle between the plane of the coil and the field

At first the plane of the coil is parallel to the field, so the torque is maximum, and after a quarter of a turn it becomes perpendicular to the field.

So the torque decreases until it becomes zero.

87 **Answer (B)**

$\tau = NBIA$ because the plane of the coil is parallel to the field

$I = (\tau)/NBA = 20/(200 \times 0.4 \times 0.03) = 8.33\ A$

88 **Answer (D)**

$\tau = NBIA\sin\theta$, where θ is the angle between the normal to the coil and the field

$\tau = 500 \times 0.25 \times 10 \times 0.2 \times \sin 30^\circ = 125\ N.m$

89 **Answer (B)**

$A = 0.2 \times 0.1 = 0.02\ m^2$

The angle between the plane and the field is 60°, so the angle between the normal and the field is 30°

$\tau = NBIA\cos 60^\circ = 200 \times 0.4 \times 3 \times 0.02 \times 0.5 = 2.4\ N.m$

90 **Answer (D)**

The plane of the coil is perpendicular to the field, i.e. the normal to the coil is parallel to the field:

$\theta = 0^\circ$

$\tau = NBIA\sin 0^\circ = 0$

91 **Answer (C)**

The plane of the coil is parallel to the field: the torque is maximum.

$\tau = NBIA = 200 \times 0.4 \times 3 \times 0.02 = 4.8\ N.m$

92 **Answer (D)**

The torque $\tau = NBIA\cos\varphi$, where φ is the angle between the plane of the coil and the field, so it decreases as the plane gets closer to being perpendicular to the field

The angle drawn is between the plane and the field: (D) 80° is the closest to 90°, so $\cos 80^\circ = 0.17$ is the smallest

(A) $\cos 0^\circ = 1$, (B) $\cos 60^\circ = 0.5$ and (C) $\cos 120^\circ = -0.5$ (magnitude 0.5)

93 **Answer (A)**

The field is in the plane of the page and parallel to the door, so the torque is maximum: $\tau = NBIA$

$I = (\tau)/NBA = 400/(50 \times 4 \times 2) = 1\ A$

Side AB moves out of the page and the field is to the right, so by the right-hand rule the current is downward, i.e. from A to B

94 **Answer (B)**

In the main figure the coil is parallel to the field, so the torque is maximum $\tau = NBIA$

To get $(\tau)/2$ we need $\cos\varphi = 1/2 \Rightarrow \varphi = 60^\circ$ between the plane and the field

95 **Answer (D)**

The coil starts from the position perpendicular to the field, so the torque is zero: $\tau = NBIA\sin\theta$

The torque increases up to 90° (maximum value), then decreases to zero at 180°

96 **Answer (D)**

The two frames have the same area $(2\ell \times \ell)$, the same current and the same position relative to the field

$\tau = NBIA$, so they are equal: $(\tau_x)/(\tau_y) = 1/1$

97 **Answer (D)**

The plane is parallel to the field, so the torque is $\tau = BIA$ and depends only on the area

We estimate the areas by counting the grid squares: the rhombus $x \approx (5 \times 5)/2 = 12.5$, the rectangle $y = 1 \times 6 = 6$, the circle $z = \pi \times 2.5^2 \approx 19.6$

$\tau_z > \tau_x > \tau_y$

98 **Answer (A)**

$\Phi_{max} = BA = 0.2\ Wb$

$\tau_{max} = NBIA = N\,I\,\Phi_{max} = 50 \times 2 \times 0.2 = 20\ N.m$

99 **Answer (D)**

Points a and b are next to each other, so the current flows through almost the whole ring: $I = V/R = 9/0.1 = 90\ A$

The ring is one turn and its plane is parallel to the field: $\tau = BIA = 0.4 \times 90 \times 3.14 \times (0.2)^2 = 4.52\ N.m$

100 **Answer (D)**

Length of the wire $L = N\,(2\pi\, r_c)$, and its resistance $R = (\rho\, L)/(\pi\, r^2) = (7 \times 10^{-7} \times N \times 2\pi \times 0.1)/(\pi \times (10^{-3})^2) = 0.14\ N\ \Omega$

$I = V/R = 14/0.14N = 100/N$

$\tau = NBIA = N \times 0.5 \times 100/N \times 3.14 \times (0.1)^2 = 1.57\ N.m$ (it does not depend on N)

101 **Answer (D)**

The two wires carry opposite currents, so their fields between them are in the same direction, and the frame is symmetric between them.

Side ab has a current in the same direction as the left wire, so it is attracted to it, and side cd is attracted to the right wire with the same force, so the two forces are equal and opposite

The forces on sides bc and ad are equal and opposite along one line, so the resultant and the torque are zero: it is not acted on by a torque

102 **Answer (D)**

$\tau = NBIA\cos\varphi$, where φ is the angle between the plane of the coil and the field, and $\tau_0 = NBIA$

The component of side PR along the field $= 5\ cm$ of $10\ cm$, so $\cos\varphi = 5/10 = 1/2$

$\tau = 1/2\tau_0$

103 **Answer (C)**

The torque becomes zero when the plane of the coil becomes perpendicular to the field, i.e. at 90°

Coil x is at 60°, so after rotating 60° it becomes 120° or 0°, so it does not become zero

Coil y is at 30°, so after rotating 60° it becomes 90°, so its torque becomes zero

104 **Answer (C)**

Side bc (length $5\ cm$) is perpendicular to the axis of rotation and makes 60° with the field: $F = BI\ell\sin 60^\circ = 0.5 \Rightarrow BI = 0.5/(0.05 \times 0.866) = 11.55$

$\tau = BIA\cos 60^\circ = 11.55 \times (0.05 \times 0.1) \times 0.5 = 0.029 \approx 0.03\ N.m$

105 **Answer (A)**

$\tau = mB\sin\theta$, where θ is the angle between the dipole moment and the field

It is zero at $\theta = 0^\circ$ or 180°, i.e. when the dipole moment is parallel to the field

106 **Answer (A)**

Dipole moment $m = NIA$

First case: one turn of side $8\ cm$: $m_1 = I \times 64 = 64I$

Second case: 4 turns, each of side $2\ cm$: $m_2 = 4 \times I \times 4 = 16I$

$m_1/m_2 = 4$

107 **Answer (C)**

The magnetic dipole moment $m = NIA$ is a property of the coil and its current only

So it increases when the current increases, and it does not depend on the field B or on the position of the coil

108 **Answer (C)**

The current in the left side is upward, then to the right in the upper side, then downward in the right side, then to the left in the lower side: clockwise.

By the right-hand rule (fingers along the current), the thumb, i.e. the dipole moment, is perpendicular to the page, inward.

109 **Answer (C)**

$\tau = NBIA\cos 60^\circ$ because the angle between the plane and the field is 60°

$N = frac\tau BIA\cos 60^\circ = 1/(2\times 10\times 0.001\times 0.5) = 100$ turns

110 **Answer (A)**

$\tau_{max} = NBIA = 100\times 2\times 10\times 0.001 = 2\ N.m$

111 **Answer (C)**

$m = NIA = 100\times 10\times 0.001 = 1\ A.m^2$

112 **Answer (D)**

The dipole moment $m = NIA$ does not depend on the angle of rotation or on the direction of the field

So it stays constant during rotation: a horizontal line.

113 **Answer (C)**

When the field is parallel to the plane, the torque is maximum: $\tau = mB$

Slope of the line $m = (\tau)/B = 8/0.4 = 20\ A.m^2$

114 **Answer (A)**

Slope of the line $m/I = NA = 8/0.4 = 20\ m^2$

$\Phi_{max} = BA = 0.2$, so $B = (\Phi_{max})/A = (0.2\times N)/NA = (0.2\times 50)/20 = 0.5\ T$

115 **Answer (A)**

$B = (\mu_0\ N\ I)/2r \Rightarrow NI = 2rB/(\mu_0) = (2\times 0.1\times 2\times 10^{-4})/(4\pi\times 10^{-7}) = 31.8$

$m = NIA = NI\times\pi\ r^2 = 31.8\times 3.14\times 0.01 = 1\ A.m^2$

116 **Answer (B)**

$A = \pi\ r^2 = 3.14\times 10^{-4} \Rightarrow r = 0.01\ m$

$I = 2rB/(\mu_0) = (2\times 0.01\times 2\times 10^{-5})/(4\pi\times 10^{-7}) = 0.318\ A$

$m = IA = 0.318\times 3.14\times 10^{-4} = 10^{-4}\ A.m^2$

Essay questions

1 **Model answer**

Pole x is a north pole, because by applying Fleming's left-hand rule we find that the direction of the magnetic flux is from pole x to pole y.

2 **Model answer**

Before the wire is rotated: $F = F_{max} \sin\theta$

$0.1 = F_{max} \sin 60$, so $F_{max} = (\sqrt{3})/15$ N

(1) After rotating the wire 30° clockwise, $\theta = 30°$:

$F = (\sqrt{3})/15 \sin 30 = (\sqrt{3})/30$ N

(2) After rotating the wire 30° anticlockwise, $\theta = 90°$:

$F = (\sqrt{3})/15 \sin 90 = (\sqrt{3})/15$ N

3 **Model answer**

$I = V/R = 2/(\ell \times 1) = 2/(\ell)$ A

$F = BI\ell = 0.1 \times 2/(\ell) \times \ell = 0.2$ N

4 **Model answer**

From the figure: $\ell_x = \ell_y \sin 60$

$F_x/F_y = (\ell_x \sin 90)/(\ell_y \sin 60) = (\ell_y \sin 60 \times \sin 90)/(\ell_y \sin 60) = 1$

5 **Model answer**

In the experiment the two connecting wires are connected in series, so the current flows in them in opposite directions, and the resultant flux density in the region between the two wires is greater than the resultant flux density outside them.

So a magnetic force acts on the two wires, directed from the region of higher flux density (inside) to the region of lower flux density (outside), so they repel and the two wires bend.

6 **Model answer**

(1) Because the currents in the two wires are in opposite directions, the force is a force of repulsion.

(2) When switch K is closed, the potential difference across wire xy stays constant because it is connected across a battery of negligible internal resistance, so the current in it does not change, and the mutual magnetic force between the two wires stays constant.

7 **Model answer**

The magnetic force acting on a unit length of wire (2) is not affected by increasing the length of the wire parallel to it, because the facing length of the two wires is constant and the values of I_1, I_2 and d are constant.

According to the relation $F_2/(\ell_2) = (\mu I_1 I_2)/(2 \pi d)$, $F_2/(\ell_2)$ stays constant.

8 **Model answer**

Wire a: $F_a/(\ell) = (\mu I \times 2I)/(2 \pi d) + (\mu I \times 4I)/(2 \pi \times 2d) = (2 \mu I^2)/(\pi d)$

Wire b: $F_b/(\ell) = (\mu \times 2I \times 4I)/(2 \pi d) - (\mu \times 2I \times I)/(2 \pi d) = (3 \mu I^2)/(\pi d)$

Wire c: $F_c/(\ell) = (\mu \times 2I \times 4I)/(2 \pi d) + (\mu I \times 4I)/(2 \pi \times 2d) = (5 \mu I^2)/(\pi d)$

So wire c is acted on by the greatest magnetic force per unit length.

9 **Model answer**

The magnetic force acting on a unit length of wire (c) becomes zero, because at point x the magnetic flux produced by the current in wire (a) cancels the magnetic flux produced by the current in wire (b).

10 **Model answer**

The force acting on wire a: $F_a/(\ell) = (4\pi \times 10^{-7} \times 1 \times 3)/(2 \pi d) + (4\pi \times 10^{-7} \times 1 \times 2)/(2 \pi \times 2d) = (8 \times 10^{-7})/d \ N/m$ (to the right)

(1) When the current in wire b is reversed: $F_a/(\ell) = (4\pi \times 10^{-7} \times 1 \times 3)/(2 \pi d) - (4\pi \times 10^{-7} \times 1 \times 2)/(2 \pi \times 2d) = (4 \times 10^{-7})/d \ N/m$ (to the left)

So the force acting on a unit length of wire (a) decreases to half and its direction is reversed.

(2) When the current in wire c is increased to three times its value: $F_a/(\ell) = (4\pi \times 10^{-7} \times 1 \times 3)/(2 \pi d) + (4\pi \times 10^{-7} \times 1 \times 3 \times 2)/(2 \pi \times 2d) = (1.2 \times 10^{-6})/d \ N/m$

So the resultant force acting on a unit length of wire a increases to 1.5 times its first value and its direction stays to the right.

11 **Model answer**

The force of attraction between wire xy and side AD of the frame: $F_1 = (\mu I^2 \ell)/(2 \pi d)$

The force of repulsion between wire xy and side BC of the frame: $F_2 = (\mu I^2 \ell)/(2 \pi \times 2d)$

The resultant force acting on the frame (attraction towards wire xy):

$F = F_1 - F_2 = (\mu I^2 \ell)/(2 \pi d)(1 - 1/2) = (\mu I^2 \ell)/(4 \pi d)$

12 **Model answer**

For wire z to be in equilibrium, the resultant magnetic force acting on it must be upward and equal to the weight of the wire downward.

$F_{yz} = (\mu I_y I_z \ell)/(2 \pi d) = (4\pi \times 10^{-7} \times 20 \times 20 \times 1)/(2 \pi \times 2 \times 10^{-2}) = 4 \times 10^{-3} \ N$

The magnetic force acting on wire z due to wire y is upward, and since $F_g > F_{yz}$, the force acting on wire z due to wire x must be upward, i.e. the current in wire x is in the same direction as the current in wire z

$F_g = F_{yz} + F_{xz}$

$0.01 = 4 \times 10^{-3} + (4\pi \times 10^{-7} \times I \times 20 \times 1)/(2 \pi \times 1 \times 10^{-2})$

$I = 15\ A$

13 **Model answer**

In both cases the two sides parallel to the axis of rotation of the coil are acted on by two equal forces in opposite directions:

For coil (x): the two forces do not have the same line of action, which produces a couple that rotates the coil.

For coil (y): the two forces have the same line of action, so their resultant is zero, and therefore there is no couple to rotate the coil.

14 **Model answer**

(1) By applying Fleming's left-hand rule to the two sides ab and cd, we find that the coil rotates clockwise.

(2) After a quarter of a turn, the plane of the coil becomes perpendicular to the direction of the magnetic field, so all its sides (ab, bc, cd, da) are perpendicular to the field and each of them is acted on by a magnetic force.

15 **Model answer**

$(\varphi_m)_{max} = BA = 1\ Wb$

$\tau_{max} = BAIN = 1 \times 1 \times 1 = 1\ N.m$

16 **Model answer**

(1) Mathematical relation: $F = (\mu I_1 I_2 \ell)/(2 \pi d)$, slope: $slope = (\Delta F)/(\Delta (1/d)) = (\mu I_1 I_2 \ell)/(2 \pi)$

(2) Mathematical relation: $\tau = BIAN \sin\theta$, slope: $slope = (\Delta \tau)/(\Delta I) = BAN \sin\theta$

(3) Mathematical relation: $\tau = BIAN \sin\theta$, slope: $slope = (\Delta \tau)/(\Delta \sin\theta) = BIAN$

17 **Model answer**

$I = V/R = V_B/(N R) = 2/(N \times 1) = 2/N\ A$

$\tau = BIAN = 1 \times 2/N \times 0.01 \times N = 0.02\ N.m$

18 **Model answer**

Circumference of one turn $= 2 \pi r$

$\ell = 2 \pi r N$, so $N = (\ell)/(2 \pi r)$, $A = \pi r^2$

$\tau = BIAN = BI \pi r^2 (\ell)/(2 \pi r) = 1/2\ B I r \ell$

19 **Model answer**

$\ell_1 = \ell_2$, so $2\pi r_1 N_1 = 2\pi r_2 N_2$

$N_1/N_2 = r_2/r_1 = 3/1$

$|m_d| = IAN = I\pi r^2 N$

$((m_d)_1)/((m_d)_2) = (r_1^2 N_1)/(r_2^2 N_2) = (1/3)^2 \times 3/1 = 1/3$

20 **Model answer**

By increasing the electric current in the coil by:

(1) increasing the emf of the battery.

(2) decreasing the resistance taken from R_v

21 **Model answer**

(1) $\tau = |m_d| B \sin\theta = 10 \times 0.1 \sin 30 = 0.5$ N.m

(2) When the coil rotates 60° clockwise, it becomes parallel to the field.

$\tau = |m_d| B = 10 \times 0.1 = 1$ N.m

22 **Model answer**

The perimeter of each turn $= 4\ell'$, so $\ell = 4\ell' N$, and $\ell' = (\ell)/4N$

The area of each turn: $A = (\ell')^2 = ((\ell)/4N)^2$

$|m_d| = IAN = I \times ((\ell)/4N)^2 \times N = (I\ell^2)/(16N)$

Past exam questions

1	2	3	4	5	6	7	8	9	10
A	A	A	A	B	C	A	B	C	B
11	12	13	14	15	16	17	18	19	20
D	A	B	A	A	B	A	B	C	C
21	22	23	24	25	26	27	28	29	30
D	D	A	C	A	B	A	A	A	B
31	32	33	34	35	36	37	38	39	40
A	B	B	C	A	D	A	A	D	A
41	42	43	44	45	46	47	48	49	50
C	A	C	A	B	D	A	C	B	A
51	52								
C	C								

1 **Answer (A)**

The field of wire (2) at wire (1) is out of the page (right-hand rule).

By Fleming's left-hand rule, the current is to the left and the field is out of the page, so the force is towards the top of the page.

2 **Answer (A)**

$slope = F/B = 10/5 = 2$

$F = 2 \times 3 = 6\ N$

3 **Answer (A)**

$F = F_{max}\ sin\theta$

$1/2\ F_{max} = F_{max}\ sin\theta$, so $\theta = 30^\circ$

4 **Answer (A)**

$F = BI\ell\ sin\theta$, so the slope $= BI\ell$

Wire X has the greatest slope, so it is the longest.

5 **Answer (B)**

$F = BI\ell$, and wire y carries 2I, so $F_y > F_x$

By Fleming's left-hand rule, the current is to the left and the field is out of the page, so the force is upward.

6 **Answer (C)**

Slope $= BI\ell$

Slope of (x) $= tan\ 60 = \sqrt{(3)}$ and slope of (y) $= tan\ 30 = 1/(\sqrt{(3)})$

$(I_x\ \ell_x)/(I_y\ \ell_y) = 3$, so $(\ell_x)/(\ell_y) = 3 \times 4/3 = 4/1$

7 **Answer (A)**

The force on ab is to the right and the force on bc is downward, and they have the same magnitude.

The resultant is at 45°, towards point Y.

8 **Answer (B)**

Moving the slider towards B decreases the resistance taken from the rheostat, so the current increases.

So the force $F = BI\ell$ increases, and the direction of the current does not change, so the force keeps its direction.

9 **Answer (C)**

$F_2 = F_{max}$ at 90°, $F_1 = F_{max} \sin X$

$F_2/F_1 = 1/(\sin X) = (2\sqrt{(3)})/3$, so $\sin X = (\sqrt{(3)})/2$, $X = 60°$

10 **Answer (B)**

The wire is parallel to the field, so the force starts from zero.

$F = F_{max} \sin\theta$ increases up to its maximum value at 90°

11 **Answer (D)**

By Fleming's left-hand rule, the magnetic force is downward, in the direction of the weight.

Resultant $= F + 2F = 3F$

12 **Answer (A)**

The wire on the axis of the solenoid is parallel to the field lines, so it is not acted on by a force.

$F = BI\ell \sin 0 = 0$

13 **Answer (B)**

The electron is a negative charge, so its direction of motion is opposite to the direction of the current.

By Fleming's left-hand rule, the force is west in the plane of the page.

14 **Answer (A)**

The force arises because the flux densities above and below the wire are different, so it moves from the higher to the lower.

15 **Answer (A)**

The wire is perpendicular to the field in the three positions, and has the same length and current.

$F = BI\ell$ is equal.

16 **Answer (B)**

Increasing R_1 decreases the total current, and decreasing R_2 makes most of the current pass through it instead of the wire.

So the current in XY decreases and the force decreases.

17 **Answer (A)**

Stretching the wire to twice its length makes its resistance 4 R, so the current decreases to a quarter.

$F' = B\ I/4\ (2\ell) = F/2$

18 **Answer (B)**

The force from y on x (attraction, to the right): $F/(\ell) = (2 \times 10^{-7} \times 3 \times 4)/0.3 = 8 \times 10^{-6}$ N/m

The force from the field on x, to the left: $3B$

$3B - 8 \times 10^{-6} = 2 \times 10^{-5}$, so $B = 9.3 \times 10^{-6}$ T

19 **Answer (C)**

$F/(\ell) = (\mu I_1 I_2)/(2 \pi d)$

$4 \times 10^{-5} = (2 \times 10^{-7} \times 2 \times I)/0.1$, so $I = 10$ A

20 **Answer (C)**

The force from y on z (attraction, to the left): $(2 \times 10^{-7} \times 5 \times 6)/0.4 = 1.5 \times 10^{-5}$ N/m

The force from the field on z, to the left: $BI = 2.5 \times 10^{-5} \times 6 = 1.5 \times 10^{-4}$ N/m

Resultant $= 1.65 \times 10^{-4} \approx 1.7 \times 10^{-4}$ N/m

21 **Answer (D)**

$F = (\mu I_1 I_2 \ell)/(2 \pi d) = (2 \times 10^{-7} \times 2 \times 4 \times 1.6)/0.2 = 1.28 \times 10^{-5}$ N

22 **Answer (D)**

Side ad has a current opposite to X (repulsion pushing X to the left): $F_1 = (2 \times 10^{-7} \times 2 \times 4 \times 0.3)/0.04 = 1.2 \times 10^{-5}$ N

Side bc has a current in the same direction as X (attraction to the right): $F_2 = (2 \times 10^{-7} \times 2 \times 4 \times 0.3)/0.14 = 3.43 \times 10^{-6}$ N

$F = F_1 - F_2 = 8.57 \times 10^{-6}$ N to the left

23 **Answer (A)**

The facing length of the two wires is 0.5 m

$F = (2 \times 10^{-7} \times 2 \times 4 \times 0.5)/0.3 = 2.67 \times 10^{-6}$ N

24 **Answer (C)**

$R = (\rho_e \ell)/A$ decreases to a quarter, so the current in X increases to 4 times its value.

$F \propto I_X I_Y$, so it becomes 4F

25 **Answer (A)**

Taking $k = (\mu)/(2\pi)$: $F_x = k(3/0.2 + 2/0.4) = 20k$

$F_y = k(6/0.2 - 3/0.2) = 15k$

$F_z = k(6/0.2 + 2/0.4) = 35k$

$F_y < F_x < F_z$

26 **Answer (B)**

The force on x is to the right (away from y), so it is a repulsion and the current is downward.

$2 \times 10^{-6} = (2 \times 10^{-7} \times 2 \times I)/0.5$, so $I = 2.5\ A$

27 **Answer (A)**

In (1) the wire is on the axis of the solenoid and in (4) on the axis of the circular coil: parallel to the field, so the force is zero.

In (2) the facing length is greater than in (3).

28 **Answer (A)**

$2.4 \times 10^{-6} = (2 \times 10^{-7} \times 2 \times I \times 0.1)/0.05$, so $I = 3\ A$

The two currents are opposite, so the force is a repulsion.

29 **Answer (A)**

The two currents are opposite, so the field is zero outside the two wires, near the one with the smaller current (Y).

$1/r = 4/(r + 3)$, so $r = 1$ division to the left of Y, i.e. at K

30 **Answer (B)**

In (B) the field of the two loops at their centre is along their axis, i.e. parallel to wire M, so it is not acted on by a force.

31 **Answer (A)**

$2 \times 10^{-5} = (2 \times 10^{-7} \times 2 \times 2 \times 0.8)/d$

$d = 0.032\ m = 3.2\ cm$

32 **Answer (B)**

The force of repulsion from O on P, to the right: $(\mu I^2 \ell)/(2 \pi d)$

The force of the field on P, to the left: $BI\ell = (\mu I^2 \ell)/(\pi d)$, which is twice as large.

So the resultant is towards the left of the page.

33 **Answer (B)**

The two currents are opposite, so the two fields add at the midpoint:

$6 \times 10^{-5} = (2 \times 10^{-7} \times 15)/0.15 + (2 \times 10^{-7} \times I_2)/0.15$, so $I_2 = 30\ A$

$F/(\ell) = (2 \times 10^{-7} \times 15 \times 30)/0.3 = 3 \times 10^{-4}\ N$

34 **Answer (C)**

On X: the force of attraction F to the right and the force of the field $2IB\ell$ to the left; the resultant is zero, so $IB\ell = F/2$

On Y: the force of attraction F to the left and the force of the field $IB\ell = F/2$ to the left.

Resultant $= 1.5\ F$

35 **Answer (A)**

MP has a current in the same direction as AB at a distance ℓ (attraction F_1), and NO has a current opposite to it at a distance 2ℓ (repulsion $F_1/2$).

$F = F_1 - F_1/2$, so $F_1 = 2F$ and $F_{NO} = F$

The resultant is an attraction, so the coil moves towards the wire and does not rotate.

36 **Answer (D)**

Taking $k = (\mu I^2)/(2\pi d)$: on X: $k - k/2 = 0.5k$

On Y: $k + k = 2k$, on Z: $k + k/2 = 1.5k$

So the smallest is wire X

37 **Answer (A)**

$1.2 \times 10^{-5} = (2 \times 10^{-7} \times I \times 1.5\ I)/0.1$

$I^2 = 4$, so $I = 2\ A$

38 **Answer (A)**

$B = (\mu I)/(2\pi d) + (\mu (2I))/(2\pi (2d)) = (2\mu I)/(2\pi d)$, i.e. $(\mu I)/(2\pi d) = B/2$

$F/(\ell) = (\mu (2I)\ I)/(2\pi d) = 2I \times B/2 = BI$

39 **Answer (D)**

$\tau = BIAN\sin\theta = 0.3 \times 2 \times 10 \times 10^{-4} \times 30 \times \sin 30$

$\tau = 9 \times 10^{-3}\ N.m$

40 **Answer (A)**

The coil is parallel to the field: $\tau = |m_d|\ B = 0.3 \times 2 = 0.6\ N.m$

41 **Answer (C)**

The angle between the plane of the coil and the field is 60°: $\tau = BIAN\cos 60$

$\tau = 2 \times 2 \times (0.1 \times 0.02) \times 2 \times 0.5 = 8 \times 10^{-3}\ N.m$

42 **Answer (A)**

$\tau = \tau_{max} \sin 60$

$\tau_{max} = 0.86/0.866 \approx 1\ N.m$

43 **Answer (C)**

The angle between the plane of the coil and the field is (θ): $\tau = |m_d|\ B \cos\theta$

$(|m_d|)/(\tau) = 1/(B \cos\theta) = 5$, so $\cos\theta = 1/(5 \times 0.4) = 0.5$, $\theta = 60^\circ$

44 **Answer (A)**

$\tau = BIAN \cos 55 = 0.02 \times 4 \times (0.2 \times 0.4) \times 5 \times \cos 55$

$\tau = 18.4 \times 10^{-3}\ N.m$

45 **Answer (B)**

The coil is perpendicular to the field (the field is along the normal to its plane), so the torque is zero.

46 **Answer (D)**

$\tau = |m_d|\ B \cos 60$

$(|m_d|)/(\tau) = 1/(B \times 0.5) = 4$, so $B = 0.5\ T$

47 **Answer (A)**

$\tau = |m_d|\ B \cos 60$ and $\tau = |m_d|$

$B = 1/0.5 = 2\ T$

48 **Answer (C)**

$\tau = |m_d|\ B \cos 30 = 120 \times 0.5 \times 0.866 \approx 52\ N.m$

49 **Answer (B)**

The same wire: with 3 turns the radius becomes $r/3$ and the area $A/9$

$\tau \propto AN = A/9 \times 3 = A/3$, so it becomes $(\tau)/3$

50 **Answer (A)**

$\tau = |m_d|\ B \cos 60$ (60° between the plane and the field)

$|m_d| = 14/(0.5 \times 0.5) = 56\ A.m^2$

Its direction is perpendicular to the plane of the coil by the right-hand rule, and it is out of the coil according to the direction of the current.

51 **Answer (C)**

$\tau = |m_d| B \cos\theta$

$14 = 56 \times 0.5 \times \cos\theta$, so $\cos\theta = 0.5$, $\theta = 60^\circ$

52 **Answer (C)**

$\ell = 2\pi r$, so $r = (\ell)/(2\pi)$

$A = \pi r^2 = (\ell^2)/(4\pi)$

$|m_d| = IA = (I\ell^2)/(4\pi)$